

Solar Terrestrial Probes (STP) Program

Mission Assurance Requirements

January 2002

The purpose of this document is to concisely present the safety and assurance requirements that are necessary for the STP Program. These requirements are intended to be incorporated into STP developer contract documents.

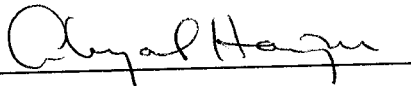
NASA Goddard Space Flight Center
Greenbelt, Maryland

CODE 460
CHECK THE STP MASTER CONTROLLED DOCUMENTS LIST AT:
<http://gdms.gsfc.nasa.gov/gdms/plsql/frontdoor>
TO VERIFY THAT THIS IS THE CORRECT VERSION

Solar Terrestrial Probes (STP) Program

Mission Assurance Requirements

Approved by:

 1-23-02

STP Program Manager

CHANGE HISTORY LOG

Revision	CCR Number	Effective Date	Section
Baseline	460-25	1/24/02	All

TABLE OF CONTENTS

CHAPTER 1.	OVERALL REQUIREMENTS	1
1.0	GENERAL.....	1
1.1	DESCRIPTION OF OVERALL REQUIREMENTS.....	1
1.2	USE OF MULTI-MISSION OR PREVIOUSLY DESIGNED, FABRICATED, OR FLOWN HARDWARE.....	2
1.3	SURVEILLANCE OF THE DEVELOPER	2
1.4	SR&QA VERIFICATION.....	2
1.5	APPLICABLE DOCUMENTS (CHAPTER 15).....	2
1.6	ACRONYMS AND GLOSSARY (CHAPTER 16)	2
CHAPTER 2.	QUALITY MANAGEMENT SYSTEM.....	3
2.0	QUALITY MANAGEMENT SYSTEM	3
2.1	SUPPLEMENTAL QA MANAGEMENT SYSTEM REQUIREMENTS	3
2.1.1	Nonconformance Documentation and Control.....	3
2.1.2	Material Review Board	3
2.1.3	Reporting of Failure	3
2.1.4	Control of Monitoring and Measuring Devices	4
2.1.5	Configuration Management	4
2.2	GROUND SUPPORT EQUIPMENT	4
2.3	REQUIREMENTS FLOW-DOWN	4
CHAPTER 3.	SYSTEM SAFETY REQUIREMENTS	5
3.0	GENERAL REQUIREMENTS	5
3.1	SYSTEM SAFETY IMPLEMENTATION PLAN.....	5
3.2	SAFETY PACKAGE.....	5
3.3	GROUND OPERATIONS PROCEDURES	6
3.4	SAFETY NONCOMPLIANCE REQUESTS	6
3.5	LAUNCH SITE SAFETY PLAN	6
3.6	SUPPORT FOR SAFETY WORKING GROUP MEETINGS	6
3.7	ORBITAL DEBRIS ASSESSMENT	6
CHAPTER 4.	RELIABILITY REQUIREMENTS.....	7
4.0	GENERAL REQUIREMENTS	7
4.1	RELIABILITY PROGRAM PLAN (RPP).....	7
4.2	RELIABILITY ANALYSES	7
4.2.1	Failure Modes and Effects Analysis and Critical Items List.....	7

4.2.2	Fault Tree Analysis (FTA)	8
4.2.3	Probabilistic Risk Assessment (PRA)	9
4.2.4	Parts Stress Analyses	9
4.2.5	Worst Case Analyses	9
4.2.6	Reliability Assessments and Predictions	9
4.2.7	Software Reliability	9
4.3	RELIABILITY ANALYSIS OF TEST DATA	10
4.3.1	Trend Analyses	10
4.3.2	Analysis of Test Results	10
4.4	LIMITED-LIFE ITEMS.....	10
4.5	CONTROL OF SUBDEVELOPERS AND SUPPLIERS	10
CHAPTER 5.	SOFTWARE ASSURANCE REQUIREMENTS	12
5.0	GENERAL REQUIREMENTS	12
5.0.1	Management Review.....	12
5.0.2	Peer Review.....	12
5.1	SOFTWARE QUALITY ASSURANCE	12
5.1.1	Software Quality Assurance Plan.....	12
5.1.2	Process Monitoring.....	13
5.2	SOFTWARE QUALITY ENGINEERING.....	13
5.2.1	Software Configuration Management	13
5.2.2	Software Reliability, Maintainability, Transportability	13
5.2.3	Risk Management	14
5.2.4	Status Reporting.....	14
5.3	SOFTWARE VERIFICATION AND VALIDATION	14
5.3.1	V&V Activities	14
5.3.2	Independent Verification and Validation.....	14
5.4	SOFTWARE NONCONFORMANCE REPORTING AND CORRECTIVE ACTION	14
5.5	SOFTWARE SAFETY ASSURANCE	15
5.6	SOFTWARE SECURITY ASSURANCE	15
5.7	GFE, EXISTING AND PURCHASED SOFTWARE	15
5.7.1	Firmware	15
CHAPTER 6.	RISK MANAGEMENT REQUIREMENTS	16
6.0	GENERAL REQUIREMENTS	16
6.1	RISK MANAGEMENT PLAN.....	16
6.2	PROBABILISTIC RISK ASSESSMENT (PRA) AND FAULT TREE ANALYSIS (FTA)	16
CHAPTER 7.	TECHNICAL REVIEW REQUIREMENTS	17

7.0	GENERAL REQUIREMENTS	17
7.1	PHASE B REVIEWS.....	18
7.2	PHASE C/D REVIEWS	18
7.3	PEER REVIEWS	18
7.4	REVIEW ACTION ITEM TRACKING	18
CHAPTER 8.	DESIGN VERIFICATION REQUIREMENTS	20
8.0	GENERAL REQUIREMENTS	20
8.1	SYSTEMS PERFORMANCE VERIFICATION PLAN.....	20
8.1.1	Requirements Verification Matrix	20
8.1.2	Performance Verification Procedures	21
8.1.3	Verification Reports	21
8.1.4	System Performance Verification Report	21
8.2	ENVIRONMENTAL VERIFICATION PROGRAM.....	21
8.2.1	Environmental Verification Plan.....	22
8.2.2	Environmental Verification Specification	22
8.2.3	Environmental Test Matrix (ETM).....	22
8.3	END-TO-END TEST	22
8.4	DEMONSTRATION OF FAILURE-FREE OPERATION	23
CHAPTER 9.	WORKMANSHIP STANDARDS	24
9.0	GENERAL REQUIREMENTS	24
9.1	APPLICABLE DOCUMENTS*	24
9.2	DESIGN	24
9.2.1	Printed Wiring Boards	24
9.2.2	Assemblies	25
9.2.3	Ground Systems That Interface With Space Flight Hardware	25
9.3	WORKMANSHIP REQUIREMENTS	25
9.3.1	Training and Certification	25
9.3.2	Flight and Harsh Environment Ground Systems Workmanship.....	25
9.3.3	Ground Systems (non-flight) Workmanship	25
9.3.4	Documentation	25
9.4	NEW OR ADVANCED PACKAGING TECHNOLOGIES	26
9.5	HARDWARE HANDLING	26
CHAPTER 10.	PARTS REQUIREMENTS	27
10.0	GENERAL REQUIREMENTS	27
10.1	PARTS CONTROL PLAN (PCP)	27
10.2	PARTS CONTROL BOARD (PCB)	27

10.2.1	Meetings.....	27
10.2.2	Membership	27
10.2.3	Responsibilities	27
10.2.4	Part Approval Requests	28
10.3	PARTS REQUIREMENTS	28
10.3.1	EEE Parts Selection.....	28
10.3.2	Developer Controlled Drawings.....	29
10.3.3	Custom Devices	29
10.3.4	Off the Shelf Items	29
10.3.5	Screening and Testing.....	30
10.3.6	Derating	32
10.3.7	Radiation Hardness.....	33
10.3.8	Parts Age Control.....	33
10.3.9	One lot/One date code.....	33
10.4	TRACEABILITY CONTROL FOR PARTS	33
10.4.1	Part Serial Numbers.	33
10.5	PARTS LISTS	33
10.5.1	Parts Identification List (PIL)	33
10.5.2	Project Approved Parts List (PAPL)	33
10.5.3	As-Built-Parts List (ABPL)	34
10.6	ALERTS	34
CHAPTER 11.	MATERIALS, PROCESSES, AND LUBRICATION REQUIREMENTS	35
11.0	GENERAL REQUIREMENTS	35
11.1	MATERIALS SELECTION REQUIREMENTS	35
11.1.1	Compliant Materials	35
11.1.2	Noncompliant Materials	35
11.1.3	Materials Used in "Off-the-Shelf-Hardware"	35
11.1.4	Conventional Applications.....	36
11.1.5	Nonconventional Applications.....	36
11.1.6	Polymeric Materials	36
11.1.7	Inorganic Materials	37
11.1.8	Fasteners	37
11.1.9	Lubrication.....	37
11.1.10	Magnetic Sensitivity.....	37
11.2	PROCESS SELECTION REQUIREMENTS	37
11.3	PROCUREMENT REQUIREMENTS	38
11.3.1	Purchased Raw Materials	38

11.3.2	Raw Materials Used in Purchased Products.....	38
11.4	GIDEP ALERTS.....	38
CHAPTER 12.	CONTAMINATION CONTROL REQUIREMENTS	45
12.0	GENERAL REQUIREMENTS	45
12.1	CONTAMINATION CONTROL PLAN.....	45
12.1.1	Contamination Control Verification Process.....	45
12.2	MATERIAL OUTGASSING	45
12.3	THERMAL VACUUM BAKEOUT	45
CHAPTER 13.	ELECTROSTATIC DISCHARGE (ESD) CONTROL.....	46
13.0	GENERAL REQUIREMENTS	46
13.1	APPLICABLE DOCUMENTS*	46
13.2	ELECTROSTATIC DISCHARGE CONTROL REQUIREMENTS	46
CHAPTER 14.	GIDEP ALERTS AND PROBLEM ADVISORIES	47
14.0	GENERAL REQUIREMENTS	47
14.1	GIDEP ALERT RESPONSE.....	47
CHAPTER 15.	APPLICABLE DOCUMENTS LIST.....	48
CHAPTER 16.	ACRONYMS AND GLOSSARY	50
16.0	ACRONYMS.....	50
16.1	DEFINITIONS	53

Chapter 1. Overall Requirements

1.0 GENERAL

Reliability considerations for the STP Program are bounded by programmatic demands for scientific excellence, low cost, and rapid development. As a result, systems are expected to be predominantly non-redundant or "single string." However, redundancy is encouraged where appropriate and where resources allow. A strong parts and materials program, robust reliability and quality programs for hardware and software, and significant reliance on the test program will be key factors in balancing requirements against program cost and complexity constraints. The GSFC STP Project Office will monitor the developer's activities to provide insight to their compliance with MAR requirements.

The developer shall refer to this Mission Assurance Requirements (MAR) document in developing their safety, reliability and quality assurance approach. The quality program shall be modeled after ANSI/ASQC Q9001-2000, "Quality Systems - Model for Quality Assurance in Design, Development, Production, Installation, and Servicing".

The developer is encouraged to make maximum use of existing practices and procedures in developing and implementing their safety, reliability and quality assurance program. The developer may offer an alternate method of meeting the intent of a requirement when such a method is better aligned with the manner in which the total work is to be accomplished, subject to GSFC Project approval. The developer shall describe the plans for maintaining adequate internal documentation for all safety, reliability and quality assurance activities and for providing NASA with essential deliverable documentation. Upon request, all developer documents utilized shall be available for GSFC Project Office review.

1.1 DESCRIPTION OF OVERALL REQUIREMENTS

This document presents a concise statement of the STP Program Mission Assurance Requirements (MAR). This MAR is applicable for the Magnetospheric Multiscale (MMS), Geospace Electrodynamics Connections (GEC), and Magnetospheric Constellation (MC) missions.

The developer shall plan and implement an organized safety, reliability and quality assurance (SR&QA) program for flight hardware, software and ground support equipment as defined in this MAR. The developer shall support and participate with the STP Project at GSFC in validating and periodically reviewing the SR&QA program.

Managers of assurance activities shall have direct access to developer management independent of project management, with the functional freedom and authority to interact with all other elements of the project. The developer shall direct issues requiring project management attention through the GSFC Project Manager and Contracting Officer's Technical Representative.

The developer shall create and submit a Product Assurance Implementation Plan (PAIP), for GSFC Project approval, that details their method of implementing the safety, reliability and quality assurance requirements contained in this MAR. The preferred format for the PAIP is the requirements sequence in this MAR.

The PAIP shall describe the developers' system for planning, documentation, and controls that will ensure complete traceability through all phases of the manufacturing, assembly, and testing of deliverable items. The developer shall prepare the PAIP and submit it in accordance with the CDRL

The PAIP shall include:

- An overview of the developer's plan for accomplishing the assurance activities required by this MAR.
- Specific and detailed description of how the performance assurance requirements are to be accomplished. Referenced documents that provide the required details shall be submitted with the PAIP.
- The rationale for any planned noncompliance to the MAR including the details of the developer's alternate approach, if any, to meet the specific MAR requirement.

1.2 USE OF MULTI-MISSION OR PREVIOUSLY DESIGNED, FABRICATED, OR FLOWN HARDWARE

When hardware that was designed, fabricated, or flown on a previous project is considered to have demonstrated compliance with some or all of the requirements of this document such that certain tasks need not be repeated, the developer shall demonstrate how the hardware complies with requirements, and provide documented objective evidence of the compliance to the GSFC Project Office for review and concurrence.

1.3 SURVEILLANCE OF THE DEVELOPER

The work activities, operations, and documentation performed by the developer, their suppliers, and partners are subject to evaluation, review, audit, and inspection by government designated representatives from GSFC, the Government Inspection Agency (GIA), or an independent assurance contractor (IAC). GSFC will delegate in-plant responsibilities and authority to those agencies via a letter of delegation, or the GSFC contract with the IAC.

1.3.1 NASA Access

The developer shall grant access for NASA and NASA representatives to conduct an assessment or survey upon notice. The developer, upon request, shall provide government assurance representatives with documents, records, and equipment required to perform their assurance and safety activities. The developer shall also provide the government assurance representative(s) with an acceptable work area within developer facilities.

1.3.2 Flow-Down

The developer(s) QA and safety programs shall ensure flow-down of requirements (e.g. technical, safety, parts, reliability, materials and QA) to all suppliers and partners (domestic and international), including a process to verify compliance. Specifically, contract review and purchasing processes shall indicate the processes for documenting, communicating, and reviewing requirements with sub-tier suppliers to ensure requirements are met.

1.4 SR&QA VERIFICATION

The STP System Assurance Manager (SAM) will periodically validate the developers' overall SR&QA program to inform the project office of potential problems or concerns. Upon request, the developer shall provide the STP project or designated assurance representatives, with assurance and safety documents, and access needed to support these activities, including access to all developer STP SR&QA databases.

1.5 APPLICABLE DOCUMENTS (CHAPTER 15)

To the extent referenced herein, applicable portions of the documents listed in Chapter 15 form a part of this document.

1.6 ACRONYMS AND GLOSSARY (CHAPTER 16)

Chapter 16 defines acronyms and terms as applied in this document.

Chapter 2. Quality Management System

2.0 QUALITY MANAGEMENT SYSTEM

The developer shall implement a Quality Management System that is compliant with the minimum requirements of ANSI/ISO/ASQ Q9001:2000 or equivalent. Certificates issued to ISO 9001:1994 will have a maximum validity of 3 years from the publication date of ANSI/ISO/ASQ Q9001:2000. The developer's Quality Manual shall be provided upon request.

2.1 SUPPLEMENTAL QA MANAGEMENT SYSTEM REQUIREMENTS

The following requirements supplement ANSI/ISO/ASQ Q9001:2000:

2.1.1 Nonconformance Documentation and Control

The developer shall have a system for identifying and reporting hardware and software nonconformances through a closed loop reporting system; ensuring that positive corrective action is implemented to preclude recurrence and verification of the adequacy of implemented corrective action by audit and test as appropriate. The developer shall provide the respective STP Project with documentation describing how nonconforming material is designated, controlled, and segregated from normal production flow. The document shall describe in detail the approval authority for accepting the disposition with government concurrence, and how the documentation is controlled, i.e. Material Review Boards (MRB).

2.1.2 Preliminary Review

A preliminary review process shall be initiated with the identification and documentation of a nonconformance. A preliminary review shall be the initial step performed by developer-appointed personnel to determine if the nonconformance is minor and can readily be processed using the following disposition actions:

- a) Scrapped, because the product is not usable for the intended purposes and cannot be economically reworked or repaired.
- b) Re-worked, to result in a characteristic that completely conforms to the standards or drawing requirements.
- c) Returned to supplier, for rework, repair or replacement.
- d) Repaired using a standard repair process previously approved by the MRB and government Quality Assurance (QA) organization.
- e) Referred to MRB when the above actions do not apply to the nonconformance.

2.1.3 Material Review Board

The GSFC STP Project SAM, or his delegated representative, shall be kept informed of MRB meeting schedules and agenda with sufficient advance notice to permit GSFC participation, if desired. The developer shall provide GSFC STP Project access to their STP material discrepancy-reporting database (read only, with download capability). The GSFC STP Project SAM, or his delegated representative, reserves disapproval rights on MRB decisions.

2.1.4 Reporting of Failure

The developer shall report flight hardware failures to the STP Project at GSFC beginning with the first power on application tests at the component level (or above) of flight hardware; or the first operation of a mechanical item. Reporting shall continue through successful closure by the Failure Review Board (FRB).

Failures shall be reported within one business day of occurrence. Failure reports documenting the failure and investigation shall be supplied to the STP Project SAM within 5 business days of the occurrence.

Developer review/disposition/approval of failure reports shall be described in applicable procedures included or referenced in the PAIP. Monthly, the developer shall provide to GSFC a list of all open failure reports and a separate list of the failure reports closed during the month.

The GSFC STP Project SAM, or a delegated representative, shall be kept informed of FRB meeting schedules and agenda with sufficient advance notice to permit GSFC participation, if desired. The developer shall provide GSFC access to their STP failure-reporting database (read only, with download capability). The GSFC STP Project Manager reserves disapproval rights on failure report dispositions prior to Observatory I&T and final approval of all failure report dispositions starting at the first instrument I&T with the spacecraft.

The software problem reporting, documentation, and disposition system defined in Section 5.4 shall be similar to (or the same as) and electronically compatible with the failure reporting system defined in this Section.

2.1.5 Control of Monitoring and Measuring Devices

Testing and Calibration Laboratories shall be compliant with the requirements of ISO 17025 – General Requirements for the Competence of Testing and Calibration Laboratories.

2.1.6 Configuration Management

The developer shall perform configuration management (CM) in support of the STP Project. The developer shall document the CM process in the PAIP or in a separate document submitted to GSFC. The configuration of deliverable items shall be maintained throughout all phases of assembly and test. Configuration verification shall be performed and documented as assemblies are incorporated into higher level assemblies and at major project milestones (i.e. pre-environmental test, pre-ship, pre-launch, etc). The CM system shall have a change classification and impact assessment process that results in Class 1 changes being forwarded to the STP Project for disposition. Class 1 changes are defined as major changes that affect mission requirements, system safety, cost, schedule, and external interfaces. All other changes are considered to be Class II changes.

Any flight item that is found to be non-compliant with the requirements of the SOW or the MAR and is not reworked to be compliant, or is not replaced with a compliant item, shall be dispositioned via a waiver. The developer shall submit Class I waivers to the GSFC STP project office for final approval. Waivers that affect mission requirements, system safety, cost, schedule, and external interfaces are to be processed as Class I. All other waivers are processed as Class II.

Software CM is further defined in Section 5 of this MAR

2.2 GROUND SUPPORT EQUIPMENT

Mechanical and electrical Ground Support Equipment (GSE) and associated software that directly interfaces with flight deliverable items shall be assembled and maintained to the same standards as the deliverable flight items, especially calibration control and configuration management. Parts and materials selection and reporting requirements are excepted as long as deliverable flight item contamination requirements are not compromised. Problem reporting shall begin with the first use with deliverable flight items and shall continue for the duration of the project. The developer PAIP shall address all GSE issues.

2.3 REQUIREMENTS FLOW-DOWN

The developer's QA and safety programs shall ensure flow-down of technical requirements to all suppliers, along with a process to verify compliance. The developer's Contract Review and Purchasing processes shall indicate the process for documenting, communicating, and reviewing requirements with sub-tier suppliers to ensure requirements are met.

Chapter 3. System Safety Requirements

3.0 GENERAL REQUIREMENTS

The system safety program shall be implemented by all spacecraft and instrument developers for flight hardware, flight ground system equipment, associated software and support facilities. This is a mandatory contract element and shall be placed directly into the contract SOW, technical specification or other direct contract requirements, including the Contract Data Requirements List for mandatory safety deliverables.

The developer shall implement a system safety program in accordance with the contractual and regulatory requirements. The system safety program shall be initiated in the concept phase of design and continue through all phases of the mission as defined by the applicable requirements documents listed below. The developer shall implement a program that provides for early identification and control of hazards during design, fabrication, test transportation, and ground activities.

The developer shall plan and implement a system safety program that accomplishes the following:

- a. Identifies and controls hazards to personnel, facilities, support equipment, and the flight system during all stages of project development. The program shall address hazards in the flight hardware, associated software, ground support equipment, and support facilities;
- b. Meets the system safety requirements of EWR 127-1 "Eastern and Western Range Safety Requirements";
- c. Meets KHB 1710.2D, "Kennedy Space Center Safety Practices Handbook";
- d. Meets NHB 1700.1 "NASA Safety Policy and Requirements Document".
- e. Meets the baseline industrial safety requirements of the institution, EWR 127-1, and any special contractually imposed mission unique obligations.
- f. Meets Facility Safety Requirements mandated by the launch vehicle contractor.

3.1 SYSTEM SAFETY IMPLEMENTATION PLAN

The developer shall prepare a System Safety Implementation Plan (SSIP), that describes the systems safety implementation process for each flight mission which includes analysis, reduction, and/or elimination of hazards that may cause the following:

- a. Loss of life or injury/illness to personnel;
- b. Damage to or loss of equipment or property (including software);
- c. Unexpected or collateral damage as a result of tests;
- d. Failure of mission;
- e. Loss of system availability;
- f. Damage to the environment.

3.2 SAFETY PACKAGE

The developer shall submit a Missile System Prelaunch Safety Package (MSPSP) consistent with the design maturity of the program at each of the phase C/D independent reviews, up to and including the Pre-shipment Review in accordance with the CDRL. The contents of each package shall be consistent with the requirements of the Eastern/Western Test Range requirements of EWR 127-1 and NASA safety KHB 1710.2D requirements.

Early in the design phase and continuing through the development effort, the developer shall identify the hazards, hazard controls, verification and tracking methods, and establishes a "closed-loop" process for each identified hazard associated with the flight system, ground support equipment, and their interfaces. The MSPSP shall include, as a minimum, a detailed description of the payload design sufficient to support hazard analysis results, hazard analysis method, and other applicable safety related information. It may be necessary to conduct tests to determine

if certain hazards exist. All hazards affecting personnel, launch vehicle hardware, or the spacecraft shall be identified. The analysis shall be updated as the hardware progresses through the stages of design, fabrication, and test. Operations that may require analyses include handling, transportation, functional tests, and environmental tests. The MSPSP shall be submitted for approval in accordance with the milestones required by the Eastern/Western Test Range safety regulation. A list of all hazardous/toxic materials and associated material safety data sheets shall be prepared and included in the final MSPSP.

3.3 GROUND OPERATIONS PROCEDURES

The developer shall submit, in accordance with the contract schedule, all ground operations procedures to be used at GSFC facilities, other integration facilities, or the launch site in accordance with the CDRL. All hazardous operations, as well as the procedures to control them shall be identified and highlighted. All launch site procedures shall comply with the launch site and NASA safety regulations.

3.4 SAFETY NONCOMPLIANCE REQUESTS

When a specific safety requirement cannot be met, the hardware developer shall submit an associated safety noncompliance request to the respective STP Project Office at GSFC for review and approval that identifies the hazard and shows the rationale for approval of a noncompliance, as defined by applicable launch range requirements.

3.5 LAUNCH SITE SAFETY PLAN

The developer with overall safety responsibility shall submit a Payload Organization Launch Site Safety Plan (LSSP) consistent with applicable launch range requirements in accordance with the CDRL.

3.6 SUPPORT FOR SAFETY WORKING GROUP MEETINGS

The developer(s) shall provide technical support to the respective STP Project Office at GSFC for safety working group meetings, Technical Interface Meetings, and technical reviews, when necessary.

3.7 ORBITAL DEBRIS ASSESSMENT

Each developer responsible for an STP Project Observatory shall supply an Orbital Debris Assessment or the information required to produce the assessment consistent with NASA-STD-8719.14, Guidelines and Assessment Procedures for Limiting Orbital Debris in accordance with the CDRL. The developer shall develop the debris assessment in accordance with the NASA policy NPD 8710.3, "NASA Policy for Limiting Orbital Debris Generation". Instruments shall provide inputs to the assessment as required by the respective Observatory Developer.

Chapter 4. Reliability Requirements

4.0 GENERAL REQUIREMENTS

Early in the preliminary design process the developer shall identify specific reliability concerns and the steps being taken to mitigate them. Reliability analyses of the design shall be conducted in accordance with the following sections. These analyses shall be reviewed with the respective STP Project Reliability Engineer as they are developed and iterated, and reported in detail at the phase C/D formal design reviews (see Chapter 7).

The Reliability program shall:

- a. Use Probabilistic Risk Assessments (PRA) to assess, manage, and, if necessary, quantitatively assess the need to reduce program risk;
- b. Demonstrate that redundant functions, including alternative paths and work-arounds, are independent to the extent practicable;
- c. Demonstrate that the stress applied to parts is not excessive;
- d. Identify single failure items/points, their effect on the attainment of mission objectives, and possible safety degradation;
- e. Show that the reliability design aligns with mission design life and is consistent among the systems, subsystems, and components;
- f. Identify limited-life items and ensure that special precautions are taken to conserve their useful life for on-orbit operations.
- g. Evaluate the impact of proposed engineering change(s) and waiver request(s) on reliability.
- h. Select significant engineering parameters for the performance of trend analysis to identify performance trends during pre-launch activities.
- i. Review design iterations with the goal of assuring the easy replacement of parts and components, and that redundant paths are easily monitored.

4.1 PROJECT RELIABILITY PLAN (RPP).

A Project Reliability Plan (PRP) for each STP mission shall be developed and approved by the STP Project office at GSFC in accordance with the SOW. The PRP shall describe the planned approach for the coordinated program of Reliability activities for the respective project. The plan shall identify the reliability tasks to be performed, and describe how the reliability tasks will be implemented and controlled. The PRP shall discuss the scheduling of reliability tasks relative to project milestones. The plan shall describe the activities that ensure reliability functions are an integral part of the design and development process and interact effectively with other project disciplines, including systems engineering, hardware design, and product assurance. The plan shall describe how reliability assessments will be integrated with the design process and other assurance practices to maximize the probability of meeting mission success criteria. Each developer shall describe how reliability assessments will incorporate definitions of failure as well as alternate and degraded operating modes that clearly describe plausible acceptable and unacceptable levels of performance. Degraded operating modes shall include failure conditions that could be alleviated or reduced significantly through the implementation of work-arounds.

4.2 RELIABILITY ANALYSES

Reliability analyses shall be performed concurrently with design so that identified problem areas can be addressed and corrective action taken (if required) in a timely manner. It shall utilize tools such as Failure Modes and Effects Analysis (FMEA), Fault Tree Analysis (FTA), Reliability Block Diagrams (RBB), Probabilistic Risk Assessment (PRA), Parts Stress Analyses, and Worst Case Analyses.

4.2.1 Failure Modes and Effects Analysis and Critical Items List

A Failure Modes and Effects Analysis (FMEA) shall be performed early in the design phase to identify system design problems. As additional design information becomes available the FMEA shall be refined. Failure modes shall be assessed at the component interface level. Each failure mode shall be assessed for the effect at that level of analysis, the next higher level and upward. The failure mode shall be assigned a severity category based on the most

severe effect caused by a failure. Mission phases (e.g., launch, deployment, on-orbit operation, and retrieval) shall be addressed in the analysis.

Severity categories shall be determined in accordance with Table 4-1:

TABLE 4-1. SEVERITY CATEGORIES

Category	Severity	Description
1	Catastrophic	Failure modes that could result in serious injury, loss of life (flight or ground personnel), or loss of launch vehicle.
1R		Failure modes of identical or equivalent redundant hardware items that, if all failed, could result in category 1 effects.
1S		Failure in a safety or hazard monitoring system that could cause the system to fail to detect a hazardous condition or fail to operate during such condition and lead to Severity Category 1 consequences.
2	Critical	Failure modes that could result in loss of one or more mission objectives as defined by the GSFC project office.
2R		Failure modes of identical or equivalent redundant hardware items that could result in Category 2 effects if all failed.
3	Significant	Failure modes that could cause degradation to mission objectives.
4	Minor	Failure modes that could result in insignificant or no loss to mission objectives

FMEA analysis procedures and documentation shall be performed in accordance with documented procedures. Failure modes resulting in Severity Categories 1, 1R, 1S or 2 shall be analyzed at a greater depth, to the single parts if necessary, to identify the cause of failure.

Results of the FMEA shall be used to evaluate the design relative to requirements (e.g., no single instrument failure will prevent removal of power from the instrument). Identified discrepancies shall be evaluated by management and design groups for assessment of the need for corrective action. The FMEA shall analyze redundancies to ensure that redundant paths are isolated or protected such that any single failure that causes the loss of a functional path will not affect the other functional path(s) or the capability to switch operation to that redundant path.

All failure modes that are assigned to Severity Categories 1, 1R, 1S, and 2, shall be itemized on a Critical Items List (CIL) and maintained with the FMEA report. Rationale for retaining the items will be included on the CIL. The FMEA and CIL shall be submitted to GSFC in accordance with the SOW, or as specified by the PRP. Results of the FMEA as well as the CIL shall be presented at all design reviews starting with the PDR. The presentations shall include comments on how the analysis was used to perform design trade-offs or how the results were taken into consideration when making design or risk management decisions.

4.2.2 Fault Tree Analysis (FTA)

A fault tree analyses (FTA) shall be performed that address both mission failures and degraded modes of operation in accordance with the SOW. Beginning with each undesired state (mission failure or degraded mission), the fault tree should be expanded to include all credible combinations of events/faults and environments that could lead to

that undesired state. Component hardware/software failures, external hardware/software failures, and human factors shall be considered in the analysis. See also Section 6.2.

4.2.3 Probabilistic Risk Assessment (PRA)

The developer shall perform probabilistic risk assessment (PRA) as part of the developer's reliability program. The PRA shall include an analysis of the probability (or frequency) of occurrence of a consequence of interest, and the magnitude of that consequence, including assessment and display of uncertainties. PRA shall be implemented as part of the systems engineering process, based on comprehensive systems analysis with analytical support, and repeated periodically as the design matures and new data become available. See also Section 6.2.

4.2.4 Parts Stress Analyses

The developer shall perform stress analyses on Electrical, Electronic, and Electromechanical (EEE) parts and devices, as applied in circuits within each component for conformance with the derating policy of MIL-STD-975 and the GSFC PPL (see section 5.3.1.1). The analyses shall be performed at the most stressful part-level parameter values that can result from the specified performance and environmental requirements on the assembly or component. The analyses shall be performed in close coordination with the packaging reviews and shall be required input data for component-level design reviews (see section 7.3 Peer Reviews). The analyses shall be documented, and justification shall be included for all applications that do not meet the derating criteria.

4.2.5 Worst Case Analyses

The developer shall perform worst-case analyses for critical parameters that are subject to variations that could degrade performance. Analyses or test or both shall demonstrate adequacy of margins in the design of electronic circuits, optics, electromechanical and mechanical items (mechanisms). The analyses shall consider all parameters set at worst-case limits and worst-case environmental stresses for the parameter or operation being evaluated. The analyses shall be updated as the design changes. The analyses and updates shall be made available to the STP Project upon request.

4.2.6 Reliability Assessments and Predictions

When necessary/prudent or when agreed-upon with GSFC, the developer shall perform comparative numerical reliability assessments and/or reliability predictions to:

- a. Evaluate alternative design concepts, redundancy and cross-strapping approaches, and part substitutions
- b. Identify the elements of the design which are the greatest detractors of system reliability
- c. Identify those potential mission limiting elements and components that will require special attention in part selection, testing, environmental isolation, and/or special operations
- d. Assist in evaluating the ability of the design to achieve the mission life requirement and other reliability goals and requirements as applicable
- e. Evaluate the impact of proposed engineering change and waiver requests on reliability

The developer shall describe in their assessments the level of detail of a model suitable for performing the intended functions enumerated above. The assessments and updates shall be submitted to GSFC for information in accordance with the SOW or RPP. The results of any reliability assessment shall be reported at PDR and CDR. They shall explain how the analysis was used to perform design trade-offs or how the results were taken into consideration when making design or risk management decisions.

4.2.7 Software Reliability

The developer shall develop a software reliability program concentrated on the tolerance of minor defects and the complete removal of critical defects. The software reliability program shall monitor and control defect removal, field performance, and include a model to predict the bug removal rate or number of bugs remaining based on

testing, running time, or bug count. The software reliability model may be time domain (related to the number of bugs at a given time during development), data domain (estimated by running the program for a subset of input data), axiomatic (based on laws/rules applied during the programming process), or other methods resulting from input data sets, logic paths, or other methods.

The developer shall document actions to verify that the software design and software engineering techniques improve the duration or probability of failure free performance and ensure repeatability of the software.

4.3 RELIABILITY ANALYSIS OF TEST DATA

The developer shall fully utilize test information during the normal test program to assess flight equipment reliability performance and identify potential or existing problem areas.

4.3.1 Trend Analyses

The developer shall perform trend analyses to the component level to track measurable parameters that relate to performance stability. Selected parameters shall be monitored for trends starting at component acceptance testing and continuing during the system integration and test phases. The monitoring shall be accomplished within the normal test framework (i.e., during functional tests, environmental tests, etc). The developer shall establish a system for recording and analyzing the parameters as well as any changes from the first observed value even if the levels are within specified limits. A list of parameters to be monitored and the trend analysis reports shall be available to the GSFC STP Project upon request. Trend analysis data shall be reviewed with the mission operational personnel prior to launch, and the mission operational personnel shall continue recording trends throughout mission life for early detection of possible mission failure tendencies.

4.3.2 Analysis of Test Results

The developer shall analyze test information, trend data, and failure investigations to evaluate reliability implications. Identified problem areas shall be documented and directed to the attention of developer management for action. This information shall be included in the developer's Progress Reports to the Project or it may be a separate monthly report. The results of the analyses shall be presented at design reviews. The presentations shall include comments on how the analysis was used to perform design trade-offs or how the results were taken into consideration when making design or risk management decisions.

4.4 LIMITED-LIFE ITEMS

The developer shall identify and manage limited-life items by means of a Limited-Life Plan, which shall be submitted to the GSFC STP project office for approval in accordance with the SOW. The plan shall present definitions, the impact on mission parameters, responsibilities, and a list of limited-life items, including data elements as follows: expected life, required life, duty cycle, and rationale for selection. Limited-life items include all hardware that is subject to degradation because of age, operating time, or cycles such that their expected useful life is less than twice the required life when fabrication, test, storage, and mission operation are combined. The list shall include the following data elements: item, expected life, required life, duty cycle, rationale for selection and effect on mission parameters. An item's useful life period begins with either:

- (1) Its fabrication
- (2) Installation into flight hardware, as appropriate, and ends when the orbital mission is completed.

A record tracking the pre-launch cumulative operating times or cycles on life-limited items shall be devised and implemented. The record shall begin when useful life is initiated and shall record the activity or operation stressing each item. Any items to be used which have an expected life less than the mission design life must be approved by the STP Project Manager via a waiver.

4.5 CONTROL OF SUBCONTRACTORS AND SUPPLIERS

The prime developer shall ensure that system elements obtained from partners, subcontractors and suppliers will meet the pertinent project reliability requirements. All subcontracts shall include provisions for review and evaluation of the subcontractors' and suppliers' reliability efforts by the prime developer at the prime developer's discretion, and by GSFC at its discretion.

The developer shall tailor the reliability requirements of this document in hardware and software subcontracts for the project and shall exercise necessary surveillance to ensure that subcontractors' and suppliers' reliability efforts are consistent with overall system requirements. The developer shall, as a result of this tailoring:

- Incorporate quantitative reliability requirements in subcontracted equipment specifications;
- Assure that subcontractors' have reliability programs that are compatible with the overall program;
- Review subcontractors' assessments and analyses for accuracy and correctness of approach;
- Review subcontractors' test plans, procedures, and reports for correctness of approach and test details;
- Attend and participate in subdevelopers' design reviews.
- Ensure that subcontractors' comply with the applicable system reliability requirements during the project operational phase.

Chapter 5. Software Assurance Requirements

5.0 GENERAL REQUIREMENTS

The developer shall implement a Quality Management System (QMS) that addresses software development and software assurance functions. The developer shall implement a QMS that is compliant to the minimum requirements of ANSI/ISO/ASQ 9001:2000 or equivalent. The QMS shall be applied to software and firmware developed under this contract. The management program shall be described in a Software Development Plan.

5.0.1 Management Review

The developer's management process shall provide for a series of developer-presented formal reviews chaired by a GSFC review panel. The formal review program shall consist of a Software Requirements Review (SRR), a Preliminary Design Review (PDR), a Critical Design Review (CDR), a Test Readiness Review (TRR), and an Acceptance Review (AR). The developer shall record minutes and action items during each review. The developer shall respond to actions assigned by the project as a result of each review.

Records of reviews not required by the contract but conducted by the developer in accordance with the developer's QMS, shall be available for review by GSFC upon request.

5.0.2 Peer Review

The developer shall implement a program of engineering working-level reviews (peer reviews) throughout the development life cycle to identify and resolve concerns prior to formal, system level reviews.

Topics that shall be addressed in the peer reviews include:

1. Design verification;
2. Coding;
3. Analyses and studies;
4. Safety;
5. Risk assessment, resolution and contingency plans;
6. Procurements;
7. Configuration management;
8. Testability and test planning, including test anomalies and resolution.

5.1 SOFTWARE QUALITY ASSURANCE

The developer shall plan, document and implement a software assurance program for software development activities. The developer shall identify the Software Quality Manager responsible for project software quality assurance. The software assurance program shall:

1. Ensure that assurance requirements are documented and satisfied throughout all phases of the development life cycle;
2. Detect actual or potential conditions that could degrade quality, including deficiencies and system incompatibilities, and provide a process to ensure corrective action is taken and completed;
3. Assure timely and effective preventive action by identifying root causes of deficiencies and nonconformances.

5.1.1 Software Quality Assurance Plan

The developer shall document the software assurance processes to be applied to the software development effort in a Software Quality Assurance Plan.

5.1.2 Process Monitoring

The developer's quality assurance program shall ensure:

1. Standards and procedures for management, engineering and assurance activities are specified;
2. Management, engineering, and assurance personnel adhere to specified standards and procedures;
3. All plans (e.g., configuration management, risk management, etc.) are completed and implemented according to specified standards and procedures.

The developer's quality assurance activities shall include:

1. Evaluation of specified standards and procedures;
2. Audits of management, engineering, and assurance processes;
3. Reviews of project documentation including reports, schedules, and records;
4. Monitoring of formal inspections and formal reviews;
5. Monitoring/witnessing of formal and acceptance-level software testing.

5.2 SOFTWARE QUALITY ENGINEERING

The developer shall implement a Software Quality Engineering (SQE) program that ensures requirements for reliability, maintainability, usability and safety are built into the products produced at each phase of the software development life cycle.

The SQE program shall ensure that:

1. All quality requirements are defined in a manner that is measurable or otherwise verifiable;
2. Quality requirements are considered during design of the software;
3. The software is tested/measured to verify compliance with quality requirements.

The SQE program shall include the following activities:

1. Analysis, identification, and detailed definition of all quality requirements;
2. Quality engineering evaluations of standards, design, and code;
3. Collection and analysis of metric data pertaining to quality requirements.

5.2.1 Software Configuration Management

The developer shall maintain a Software Configuration Management (SCM) system that provides control of changes to software products, beginning in the testing phase and continuing until government acceptance. SCM control shall be implemented in the development cycle no later than immediately prior to the first test for which test results must be reported to the NASA project office.

The developer shall ensure the configuration management system addresses baseline control, configuration identification, configuration control, configuration status accounting and configuration authentication. The developer shall describe the SCM system in a Software Configuration Management Plan.

5.2.2 Software Reliability, Maintainability, Transportability

The developer shall conduct a software reliability program to identify and mitigate risks of software failure. Software failure is defined as the inability to satisfy any requirement under any condition specified by that requirement. The developer shall ensure that the software engineering development program addresses requirements for maintainability and transportability.

5.2.3 Risk Management

The developer shall implement a Continuous Risk Management System (CRMS) that provides for the identification, analysis, tracking, communication, resolution, mitigation and retirement of risks. The CRMS shall include the development; maintenance; and presentation of a risk list. This list shall include a description of the risk, along with a mitigation/elimination strategy and status. The CRMS shall be implemented in accordance with the guidelines set forth by NPG 7120.5A, NASA Program and Project Management Processes and Requirements. The developer shall document the risk management program in a Risk Management Plan.

5.2.4 Status Reporting

The developer shall include in the monthly status reports to the government information that identifies software development schedules, issues and action items.

5.3 SOFTWARE VERIFICATION AND VALIDATION

The developer shall implement a Software Verification and Validation (V&V) program to ensure that software being developed or maintained satisfies functional and other requirements for each phase of the development.

5.3.1 V&V Activities

V&V activities shall be performed during each phase of the software life cycle and shall include the following:

1. Analysis of system and software requirements allocation, verifiability, testability, completeness, and consistency (including analysis of test requirements);
2. Design and code analysis including design completeness and correctness;
3. Interface analysis (requirements and design levels);
4. Formal Inspections;
5. Formal Reviews (phase transition reviews);
6. Test planning, performance, and reporting.

5.3.2 Independent Verification and Validation

The developer shall ensure that all information required for the NASA Independent Verification and Validation (IV&V) effort is made available to NASA IV&V personnel. Wherever possible, the developer shall permit electronic access to the required information. The developer shall allow NASA IV&V review and participation before final product delivery to NASA.

5.4 SOFTWARE NONCONFORMANCE REPORTING AND CORRECTIVE ACTION

The developer shall implement a process for Software Nonconformance Reporting and Corrective Action (NRCA) that addresses reporting, analyzing, and correcting nonconformances throughout the development life cycle. The developer's QMS shall provide for a corrective action process that tracks every nonconformance to its final disposition. The NRCA process for a product shall start no later than the establishment of a configuration management baseline that includes the product.

The NRCA process shall include:

1. Nonconformance detection and reporting procedures;
2. Nonconformance tracking and management procedures;
3. Nonconformance impact assessment and corrective action procedures;
4. Interfaces to the Configuration Management process.

5.5 SOFTWARE SAFETY ASSURANCE

The developer shall conduct a software safety program to identify and mitigate safety-critical software products. If any software component is identified as safety-critical, the developer shall conduct a software safety program on that component in compliance with NASA-STD-8719.13A "NASA Software Safety Standard".

The software safety program shall ensure that:

1. Safety-related deficiencies in specifications and design are identified and corrected;
2. Software design incorporates positive measures to enhance the safety of the system;.
3. Software safety is included as an agenda item for formal reviews.

The software safety process shall include the following activities:

1. Determination of the safety criticality for each software component;
2. Analysis of the consistency, completeness, correctness, and testability of safety requirements;
3. Analysis of design and code to ensure implementation of safety-critical requirements;
4. Analysis of changes for safety impact.

5.6 SOFTWARE SECURITY ASSURANCE

The developer shall conduct a software security program to identify and mitigate software security risks. The security program shall ensure that security requirements are established, documented, and implemented during all phases of the software life cycle. Software security tasks and activities shall include the addressing of security concerns during reviews, analyses, inspections, testing, and audits.

5.7 GFE, EXISTING AND PURCHASED SOFTWARE

If the developer will be provided software as government-furnished equipment (GFE), or will use existing or purchased software, the developer shall ensure that the software meets the functional, performance, and interface requirements placed upon it. The developer shall ensure that the software meets applicable standards, including those for design, code, and documentation, or shall secure a GSFC project waiver to those standards. Any significant modification to any piece of the existing software shall be subject to the provisions of the developer's QMS and the provisions of this document. A significant modification is defined as the change of twenty percent of the lines of code in the software.

5.7.1 Firmware

Developed firmware shall be subject to the same requirements as developed software. Purchased firmware shall be subject to the same requirements as purchased software.

Chapter 6. Risk Management Requirements

6.0 GENERAL REQUIREMENTS

Risk Management is a requirement established by the NPG 7120.5A, NASA Program and Project Management Processes and Requirements. The development and implementation of the project-specific Risk Management Plan will aid in performing risk assessment and risk management within the reliability and quality assurance activity. Risk Management applies to all software and hardware products and processes (flight and ground) to identify, analyze, track, and control risks and well as plan mitigation actions.

The developer shall:

- a. Search for, locate, identify, and document reliability and quality risks before they become problems
- b. Evaluate, classify, and prioritize all identified reliability and quality risks
- c. Develop and implement risk mitigation strategies, actions, and tasks and assign appropriate resources
- d. Track risk being mitigated; capture risk attributes and mitigation information by collecting data; establish performance metrics; and examine trends, deviations, and anomalies
- e. Control risks by performing risk close-out, re-planning, contingency planning, or continued tracking and execution of the current plan
- f. Communicate and document (via the risk recording, reporting, and monitoring system) risk information to ensure it is conveyed between all levels of the project
- g. Report on outstanding risk items at all management and design reviews. The GSFC Project Office, the GSFC Systems Review Office (for design reviews only), and the developer will agree on what level of detail is appropriate for each review.

6.1 RISK MANAGEMENT PLAN

The developer shall develop a Risk Management Plan for the products they are responsible for. The plan shall include risks associated with hardware (technical challenges, new technology qualification, etc), software, system safety, performance, and programmatic risks (cost and schedule). The plan shall identify which tools techniques will be used to manage the risks. The risk areas that are identified shall be addressed at the peer reviews and at independent and code 300 reviews. The government and developer's surveillance plan shall address the risk areas to ensure adequate mitigation steps are in place.

All identified reliability and quality risks shall be documented and reported on in accordance with the Project's Risk Management Plan. Risk status shall be available to the Project for review. The status of risks shall also be provided in Technical Review Reports. Although not all risks will be fully mitigated, all risks shall be addressed with mitigation and acceptance strategies agreed upon at appropriate mission reviews.

Note: The GSFC Office of Systems Safety and Mission Assurance has developed training and processes to aid GSFC and NASA missions in implementing an effective Risk Management Program. This training and assistance is available upon request from the GSFC Project Manager.

6.2 PROBABILISTIC RISK ASSESSMENT (PRA) AND FAULT TREE ANALYSIS (FTA)

The developer shall use Probabilistic Risk Assessment (PRA) and Fault Tree Analysis (FTA) (see section 4.2.2) as part of the program's risk management and reliability programs. The developer shall include specific results in their CDR and pre-CDR reviews. The developer shall make the PRA available to the STP project upon request.

Chapter 7. Technical Review Requirements

7.0 GENERAL REQUIREMENTS

The STP Project's philosophy is to focus resources early and throughout the program on engineering working level reviews to identify and resolve concerns before these issues reach formal, high-level system reviews. The developer shall conduct these engineering peer reviews. The GSFC STP Project Office will provide technical expertise for participation in the areas undergoing detailed engineering review. These reviews will be complemented by a series of phased formal reviews of the STP Project based on the STP Integrated Independent Review Plan. The plan is based on the requirements of GPG 8700.4D, "Integrated Independent Reviews". The GSFC Systems Review Office (SRO) and an external co-chair will chair the formal reviews.

The objectives of the STP Mission Assurance review program are to:

1. Assure that the spacecraft, instrument(s) and supporting designs are consistent with the STP Mission Requirements Document;
2. Assure that the characteristics of the systems are carefully examined to develop the best approach consistent with existing constraints and available resources;
3. Provide a means of periodic evaluation of the hardware, software, and ground support development;
4. Assure that end-item deliverables (systems and subsystems) meet the STP requirements for performance, schedule and cost.

The formal system level reviews will concentrate on critical system and end-to-end mission level technical and programmatic issues. The following will be formal system level reviews :

- Preliminary Design Review;
- Critical Design Review;
- Mission Operations Review;
- Pre-Environmental Review;
- Flight Operations Review;
- Pre-Ship Review;
- Flight Readiness Review.

The developer shall support the series of comprehensive system-level design reviews that are conducted by the GSFC Systems Review Office (SRO). The reviews cover all aspects of flight and ground hardware, software, and operations for which the developer has responsibility. For each specified system-level review conducted by the GSFC SRO, the developer shall:

- a. Develop and organize material for oral presentation to the GSFC review team. Copies of the presentation material will be available at each review.
- b. Support splinter review meetings resulting from the major review;
- c. Produce written responses to recommendations and action items resulting from the review;
- d. Summarize, as appropriate, the results of the developer reviews at the component and subsystem level.

The Integrated Independent Review Plan (IIRP) will be developed and maintained by the Project Manager and approved by the Deputy Director of Systems Management. The IIRP will serve as the basis for defining the process for conducting the above listed reviews. Scheduling of these reviews will be coordinated through the GSFC STP Project Office. The review co-chairs, in concert with the Project Office and other Directorates, appoints independent key technical experts as review team members. Every effort will be made to maintain the co-chairs and the key technical experts for the duration of the Project. Mission and flight operations requirements issues will be

presented at the above reviews, unless an additional formal independent review is warranted because of the complexity of the flight and ground interfaces.

7.1 PHASE B REVIEWS

Phase B formally begins with the signed contract agreement for the mission and ends with formal confirmation for the mission by NASA headquarters following a Confirmation Review (CONR). It is expected that during Phase B the mission team will hold a Preliminary Design Review (PDR) prior to the CONR.

Preliminary Design Review (PDR) – This review occurs early in the design phase prior to manufacture of engineering hardware and the detail design of associated software. Where applicable, it will include the results of test bedding, breadboard testing, and software prototyping. Long-lead procurements shall be discussed.

7.2 PHASE C/D REVIEWS

Critical Design Review (CDR) – This review occurs after the design has been completed but prior to the start of manufacturing flight components or the coding of software. It shall emphasize implementations of design approaches as well as test plans for flight systems including the results of engineering model testing.

Mission Operations Review (MOR) – This Mission-oriented review occurs before significant integration and test (I&T) of the flight systems and ground systems. Its purpose is to review the status of the system components, including the ground system, network operations, the operational interfaces with the flight system, and orbital operations plans.

Pre-Environmental Review (PER) – This review occurs prior to the start of environmental testing of the flight instrument. It will assess the readiness of the flight hardware and software, and facilities for system level test and evaluate the environmental test plans.

Flight Operations Review (FOR) – This review emphasizes the final orbital operations plans as well as the compatibility of the flight components with ground support equipment and the ground network, including summary results of the network compatibility tests.

Pre-Shipment Review (PSR) – This review shall take place prior to shipment of the observatory to the launch site. It will verify that testing has been completed with no unacceptable open issues and will evaluate the readiness of the hardware and software for flight. It will assess the adequacy of testing on flight hardware and software, verification and documentation of the hardware and software configuration, identification of outstanding safety risks, disposition of waivers/deviations/open issues, compatibility of spacecraft and ground support equipment, and orbital operations plans.

Flight Readiness Review (FRR) – This review will be conducted at the launch facility to verify overall readiness of flight hardware and software, and ground and launch support resources to achieve the mission flight objectives.

7.3 PEER REVIEWS

Engineering peer reviews of component and subsystem hardware/software chaired by the developer shall occur during all phases of the project life cycle. These reviews are expected to be the most detailed of the STP reviews. It is the intent of the peer reviews that participants generate a detailed understanding of the component and subsystem designs' ability to meet higher level system and mission requirements. Effective peer reviews will enable significant streamlining of the content of higher level formal reviews described in section 3.1 and 3.2 herein. To promote continuity of the whole review program, invitations will be extended to the Systems Review Office and the GSFC STP Project technical experts to attend peer review sessions. Detailed minutes of the peer review findings (including action items, if any) shall be provided to the GSFC STP project office within ten (10) working days after the review is conducted.

7.4 REVIEW ACTION ITEM TRACKING

The GSFC STP Project Manager will be responsible for addressing IIR Team findings and requests for action (RFAs), and for maintaining a closed loop closure process. The developer shall implement a system for tracking the status and resolution of Action Items initiated during peer and formal reviews whose status shall be reported at the formal reviews listed in paragraphs 2.1 and 2.2. Action Items shall be assigned unique control numbers that

identify the item under review and the review type (i.e. SC ACU PDR AI##, SC ACU CDR AI##, etc.) The numbering/tracking system shall be capable of differentiating Action Items of any specific system review from all other system reviews.

Chapter 8. Design Verification Requirements

8.0 GENERAL REQUIREMENTS

The developer shall conduct a system performance verification program covering the component through Observatory levels documenting the overall verification plan, implementation, and results to ensure that the spacecraft and instruments meet the specified mission requirements, and to provide traceability from mission requirements through launch and on-orbit capability. The program shall consist of a series of functional demonstrations, analytical investigations, physical property measurements, and environmental tests that simulate the environments encountered during handling and transportation, pre-launch, launch, and on-orbit. Detailed (step-by-step) verification procedures shall be prepared for each test and submitted for review and concurrence by the GSFC STP Project Office prior to implementation. The developer shall maintain as-run verification procedures, including all test and analysis data.

All flight hardware and software shall undergo qualification to demonstrate compliance with the requirements of this section. In addition, all other hardware (flight follow-on, spare and re-flight) shall undergo acceptance in accordance with the requirements of this section.

The Verification Program shall begin with functional testing at the component level of assembly. Verification continues through functional and environmental testing at the component, subsystem, spacecraft and observatory levels of assembly, supported by appropriate analysis. The program shall conclude with end-to-end testing of the entire operational hardware/software system at the observatory level including the instruments, the ground control center, and the appropriate network elements.

The General Environmental Verification Specification for STS & ELV Payloads, Subsystems, and Components (GEVS-SE), shall be used as a baseline guide for developing the verification program. Alternative methods are acceptable provided that the net result demonstrates compliance with the intent of the requirements.

8.1 SYSTEMS PERFORMANCE VERIFICATION PLAN

The developer shall submit a Systems Performance Validation Plan (SPVP) for GSFC STP Project approval in accordance with the CDRL. The system performance verification plan shall define the tasks and methods required to determine the ability of the system to meet each project-level performance requirement (structural, thermal, optical, electrical, guidance/control, RF/telemetry, science, mission operational, etc.) and to measure specification compliance. Limitations in the ability to verify any performance requirement shall be addressed, including the addition of supplemental tests and/or analyses that will be performed and a risk assessment of the inability to verify the requirement.

The plan shall address how compliance with each specification requirement will be verified. If verification relies on the results of measurements and/or analyses performed at lower (or other) levels of assembly, this dependence shall be described.

For each analysis activity, the plan shall include objectives, a description of the mathematical model, assumptions on which the models will be based, required output, criteria for assessing the acceptability of the results, the interaction with related test activity, if any, and requirements for reports. Analysis results shall take into account tolerance build-ups in the parameters being used.

8.1.1 Requirements Verification Matrix

The developer shall provide adequate documentation to demonstrate compliance with all Performance Specification Requirements (PSR) identified in the SPVP. The developer shall have a PSR Verification Matrix or equivalent system that shows the flow-down of all PSRs and the method of verification. The PSR Verification Matrix and supporting documentation shall provide the following information:

- Systems Performance Validation Plan PSR flow-down;
- Basis for verification method (test, analysis, similarity, heritage, etc.);
- Dates accomplished with name and signature of person performing the action;

- Dates verified with name and signature of person verifying performance;
- Definition of specific environments for each requirement;
- Tracking of requirements verified against those planned;
- Detailed supporting documentation of compliance with each requirement.

Use of existing documentation practices or systems that provide this information is encouraged. The PSR Verification Matrix shall be submitted to the GSFC STP Project Systems Assurance Manager in accordance with the CDRL. The PSR Verification Matrix shall be iterated as verification is completed, kept current, and the status made available at Project monthly progress meetings. The completed matrix shall be included in the Acceptance Data Package as part of delivery.

8.1.2 Performance Verification Procedures

For each verification test activity conducted at the component, subsystem, and payload levels (or other appropriate levels) of assembly, a verification procedure shall be prepared that describes the configuration of the test article, how each test activity contained in the verification plan and specification will be implemented.

Test procedures shall contain details such as instrumentation monitoring, facility control sequences, test article functions, test parameters, pass/fail criteria, quality control checkpoints, data collection, and reporting requirements. The procedures also shall address safety and contamination control provisions.

8.1.3 Verification Reports

After each component, subsystem, payload, etc. verification activity has been completed, a report shall be submitted in accordance with contract schedule. For each analysis activity, the report shall describe the degree to which the objectives were accomplished, how well the mathematical model was validated by related test data, and other such significant results. In addition, as-run verification procedures and all test and analysis data shall be retained for review.

8.1.4 System Performance Verification Report

At the conclusion of the verification program, a final system Performance Verification Report shall be delivered comparing the hardware/software specifications with the final verified values (whether measured or computed). It is recommended that this report be subdivided by subsystem/instrument.

The System Performance Verification Report shall be developed and maintained “real-time” throughout the program summarizing the successful completion of verification activities, and showing that the applicable system performance specifications have been acceptably complied with prior to integration of hardware/software into the next higher level of assembly.

8.2 ENVIRONMENTAL VERIFICATION PROGRAM

All flight hardware shall be subjected to an environmental test program sufficient to demonstrate design qualification, acceptance, and to test for workmanship. Functional testing shall be performed before, during, and after environmental tests, as appropriate.

The General Environmental Verification Specification for STS & ELV Payloads, Subsystems, and Components (GEVS-SE) shall be used for developing the environmental test portion of the verification program. Alternative methods that demonstrate compliance with mission requirements while integrating adequate safety margins may also be used. Methods for implementing the requirements of this section are contained in the expendable launch vehicle (ELV) payload requirements of the GEVS-SE (see Exhibit A herein).

The ELV payload requirements of GEVS-SE and the mission requirements establish the general environmental test requirements for the STP mission. Test levels shall encompass predictions based on launch vehicle information available in the Spacecraft to ELV interface control document.

Prototype and protoflight hardware shall undergo appropriate qualification tests to demonstrate compliance with the design requirements. Flight, flight spare, follow-on, and re-flight hardware shall undergo flight-like acceptance test levels to verify acceptable assembly workmanship.

The following environmental exposures are required as a baseline for STP. Specific environmental requirements for each STP spacecraft, instrument and component shall be shown in the verification matrix and described in the SPVP through final Observatory testing. Comprehensive Performance Tests (CPTs) shall be performed before, during, and after environmental exposures, as specified in the Verification Plan.

Components: Sine Vibration, Random Vibration, Strength, EMI/EMC, Thermal Vacuum/Thermal Balance, Mass Properties, and Deployment shall be performed. CPTs are also considered a vital part of the verification program at these levels of assembly.

Spacecraft: Strength (static or quasi-static), Low level (Pogo) Sine Vibration, Random Vibration, Acoustics, Mechanical Shock, EMI/EMC, Thermal Vacuum/Thermal Balance, Mass Properties, and Deployment shall be performed.

Repeated functional tests should be used to demonstrate the growing maturity of spacecraft subsystems, perform trending analysis, and to baseline performance status before each environmental test. CPT demonstrations shall be performed to verify full mission hardware compliance, compatibility, and operability; and to perform trending analysis.

8.2.1 Environmental Verification Plan

An environmental verification plan shall be prepared, as part of the System Verification Plan or as a separate document, that prescribes the tests and analyses that will collectively demonstrate that the hardware and software comply with the environmental verification requirements.

The environmental verification plan shall provide the overall approach to accomplishing the environmental verification program. For each test, it shall include the level of assembly, the configuration of the item, objectives, facilities, instrumentation, safety considerations, contamination control, test phases and profiles, necessary functional operations, personnel responsibilities, and requirement for procedures and reports. It shall also define a rationale for retest determination that does not invalidate previous verification activities. When appropriate, the interaction of the test and analysis activity shall be described.

Limitations in the environmental verification program that preclude the verification by test of any system requirement shall be documented. Alternative tests and analyses shall be evaluated and implemented as appropriate, and an assessment of project risk shall be included in the System Performance Verification Plan.

8.2.2 Environmental Verification Specification

The developer shall prepare an environmental verification specification to define the specific parameters associated with the planned environmental tests. Payload peculiarities and interactions with the launch vehicle shall be considered in defining these environmental parameters. These special interactions may include subjects such as resonance de-tuning, EMI/EMC effects, pyrotechnic firing disturbances, etc. The Environmental Verification Specification may be included as part of the System Performance Validation Plan

8.2.3 Environmental Test Matrix (ETM)

The hardware developer shall have an environmental test matrix or equivalent that summarizes all environmental exposures that will be performed, showing the test and the level of assembly. Tests on engineering models performed to satisfy qualification requirements shall be included in this matrix. This matrix may be combined with the verification matrix on a common database. The matrix shall be iterated as testing is completed, kept current, and status made available at Project monthly progress meetings. The completed matrix shall be included in the Acceptance Data Package as part of delivery.

8.3 END-TO-END TEST

Prior to the PSR, an end-to-end compatibility test shall be performed to demonstrate the Mission Operations Center (MOC) capability to communicate with both observatories (up-link and down-link) via the ground to space network.

Simulated normal orbital mission scenarios encompassing launch, systems turn-on, housekeeping, command/control, and stabilization/pointing shall be demonstrated, including the collecting, processing, and archiving of science data. Observatory immunity to erroneous commands, autonomous safe-hold, and simulated anomaly recovery operations shall also be demonstrated.

8.4 DEMONSTRATION OF FAILURE-FREE OPERATION

At the conclusion of the verification program, each STP instrument or observatory shall have demonstrated a period of 100 hours of failure-free operation in its simulated mission orbital environment. The demonstration may be performed at the subsystem level when the time period of demonstration cannot be practically accomplished at the system level of assembly. Major hardware changes during or after the failure-free period will invalidate any previous demonstration.

CHAPTER 9. Workmanship Standards

9.0 GENERAL REQUIREMENTS

The developer shall plan and implement a Workmanship Program to assure that all electronic packaging technologies, processes, and workmanship activities selected and applied meet mission objectives for quality and reliability. See Chapter 13 for additional information on electrostatic discharge (ESD) control.

9.1 APPLICABLE DOCUMENTS*

- Conformal Coating and Staking: NASA-STD-8739.1, Workmanship Standard for Staking and Conformal Coating of Printed Wiring Boards and Electronic Assemblies;
- Soldering – Flight, Surface Mount Technology: NASA-STD-8739.2, Surface Mount Technology;
- Soldering – Flight, Manual (hand): NASA-STD-8739.3, Soldered Electrical Connections;
- Soldering – Ground Systems: IPC/EIA JSTD-001C, Requirements for Soldered Electrical and Electronic Assemblies;
- Electronic Assemblies – Ground Systems: IPC-A-610C, Acceptability of Electronic Assemblies;
- Crimping, Wiring, and Harnessing: NASA-STD-8739.4, Crimping, Interconnecting Cables, Harnesses, and Wiring;
- Fiber Optics: NASA-STD-8739.5, Fiber Optic Terminations, Cable Assemblies, and Installation;
- Electrostatic Discharge Control (ESD): ANSI/ESD S20.20, Protection of Electrical and Electronic Parts, Assemblies and Equipment (Excluding Electrically Initiated Explosive Devices);
- Printed Wiring Board (PWB) Design:
 - IPC-2221, Generic Standard on Printed Board Design
 - IPC-2222, Sectional Design Standard for Rigid Organic Printed Boards
 - IPC-2223, Sectional Design Standard for Flexible Printed Boards;
- Printed Wiring Board Manufacture:
 - IPC A-600, Acceptability of Printed Boards
 - IPC-6011, Generic Performance Specification for Printed Boards
 - IPC-6012, Qualification and Performance Specification for Rigid Printed Boards
 - Flight Applications – Supplemented with: GSFC/S312-P-003, Procurement Specification for Rigid Printed Boards for Space Applications and Other High Reliability Uses
 - IPC-6013, Qualification and Performance Specification for Flexible Printed Boards
 - MIL-P-55110E, Printed Wiring Board, Rigid, General Specification For.

*current status and/or any application notes for these standards can be obtained at URL <http://standards.nasa.gov>

9.2 DESIGN

9.2.1 Printed Wiring Boards

The PWB manufacturing and acceptance requirements identified in this chapter are based on using PWBs designed in accordance with the PWB design standards referenced above. Space flight PWB designs shall not include features that prevent the finished boards from complying with the Class 3 Requirements of the appropriate manufacturing standard (e.g., specified plating thicknesses, internal annular ring dimensions, etc.).

9.2.2 Assemblies

The design considerations listed in the NASA workmanship standards listed above should be incorporated to the extent practical.

9.2.3 Ground Systems That Interface With Space Flight Hardware

Ground system assemblies that interface directly with space flight hardware shall be designed and fabricated using space flight parts, materials, and processes for any portion of an assembly that mates with the flight hardware; or that will reside with the space flight hardware in environmental chambers or other test facilities that simulate a space flight environment (e.g., connectors, test cables, etc.).

9.3 WORKMANSHIP REQUIREMENTS

9.3.1 Training and Certification

All personnel working on deliverable hardware shall be certified as having completed the required training, appropriate to their involvement, as defined in the above standards or in the developer's PAIP. This includes, but is not limited to, the aforementioned workmanship and ESD standards. At a minimum, certification shall include successful completion of formal training in the appropriate discipline.

9.3.2 Flight and Harsh Environment Ground Systems Workmanship

9.3.2.1 Printed Wiring Boards

PWBs shall be manufactured in accordance with the Class 3 Requirements in the above referenced PWB manufacturing standards. The developer shall provide printed wiring board (PWB) coupons to GSFC, or to a GSFC approved laboratory for evaluation in accordance with the CDRL. PWB coupon approval shall be obtained prior to population of flight PWBs. The developer may have the coupons evaluated at an alternate laboratory if written approval is obtained from the GSFC STP Project Office in advance. If an approved alternate laboratory is used, delivery of the test reports to the GSFC is required.

9.3.2.2 Assemblies

Assemblies shall be fabricated using the appropriate workmanship standards listed above (i.e., NASA-STD-8739.3 for hand soldering; NASA-STD-8739.4 for crimping/cabling; NASA-STD-8739.5 for fiber optic termination and installation; etc.).

9.3.3 Ground Systems (non-flight) Workmanship

9.3.3.1 Printed Wiring Boards

PWBs shall be manufactured in accordance with the Class 2 Requirements in the above referenced PWB manufacturing standards.

9.3.3.2 Assemblies

Assemblies shall be fabricated using the Class 2 Requirements of J-STD-001C and IPC-A-610C, and ANSI/ESD S20.20. If any conflicts between J-STD-001C and IPC-A-610C are encountered, the requirements in J-STD-001C shall take precedence.

9.3.4 Documentation

The developer shall document the procedures and processes that will be used to implement the above referenced workmanship, design, and ESD control standards; including any procedures or process requirements referenced-in via those standards.

Alternate standards may be proposed by the developer. Proposals must be accompanied by objective data that documents mission safety or reliability will not be compromised. Their use is limited to the STP project and are allowed only after they have been reviewed and approved by GSFC program management.

9.4 NEW OR ADVANCED PACKAGING TECHNOLOGIES

New and/or existing advanced packaging technologies (e.g., multi-chip modules (MCMs), stacked memories, chip on board, ball grid array (BGA), etc.) shall be reviewed, approved by the PMPCB and included in the Program Approved Parts List (PAPL) in accordance with in Section 11.2.

9.5 HARDWARE HANDLING

The handling of flight hardware shall be performed by designated personnel in accordance with approved procedures that address cleaning, handling, packaging, tent enclosures, shipping containers, bagging (e.g., antistatic film materials), and purging. Procedures for the control of contamination (detailed definition in Chapter 9) shall be implemented in all phases of assembly and test. All personnel working on flight hardware shall be certified as having completed the required courses as defined in the developers' PAIP prior to handling any flight hardware. This includes, but is not limited to, the aforementioned workmanship, design and ESD awareness courses.

Chapter 10. Parts Requirements

10.0 GENERAL REQUIREMENTS

The developer shall plan and implement an Electrical, Electronic, and Electromechanical (EEE) Parts Control Program to assure that all parts selected for use in flight hardware meet mission objectives for quality and reliability. The program shall be in place in time to effectively support the iterative design and selection processes.

10.1 PARTS CONTROL PLAN (PCP)

The developer shall prepare a Parts Control Plan (PCP) describing the approach and methodology for implementing parts control. The PCP shall also define the developer's criteria for parts selection and approval based on this section. The PCP shall be made a part of the proposal for review in accordance with contract delivery requirements.

10.2 PARTS CONTROL BOARD (PCB)

The developer shall control the selection, application, evaluation, and acceptance of all parts through a Parts Control Board, or another acceptable documented system of parts control. The Parts Control Board (PCB) shall facilitate the management and associated documentation of parts for the duration of the contract. The PCB will be responsible for the review and approval of all EEE parts, for conformance to established requirements (including radiation effects), and for developing and maintaining a Project Approved Parts List (PAPL). In addition, the PCB will be responsible for all parts activities such as failure investigations, disposition of non-conformances, and problem resolutions. PCB operating procedures shall be included as part of the PCP.

If there are any parts issues, which the developer and GSFC cannot resolve at the PCB level, then the GSFC Parts Engineer shall inform the System Assurance Manager (SAM) and the Project Manager of the issue and the associated risk. After this discussion, the GSFC Project Manager will decide whether to accept the risk and ask the developer to submit a waiver to document the issue, or to elevate the issue to the developer's management for resolution.

10.2.1 Meetings

PCB meetings shall be convened on a regular basis as needed. Teleconferencing may be used for meetings with short agendas. For large agendas, Technical Interchange Meetings (TIMs) held on-site at the developer's facilities are encouraged. During on-site PCB meetings, developer controlled documents are more assessable and when necessary, design engineers can be more easily consulted to explain items and application issues.

10.2.2 Membership

As a minimum, membership shall consist of the developer's Project Parts Engineer (PPE), the NASA System Assurance Manager (SAM) and NASA Project Parts Engineer. The PCB shall be chaired by the developer's PPE. GSFC shall have voting rights at the meetings in order to concur or veto decisions.

10.2.3 Responsibilities

10.2.3.1 Agenda

The contractor shall issue an agenda that contains a list of parts to be reviewed and where necessary, provide supporting drawings or other information. The agenda shall also include parts activities to be discussed such as failure investigations, problem resolutions, etc.

10.2.3.2 Minutes

Meeting minutes shall be distributed and maintained by the developer in order to document all decisions made at the PCB and shall include rationale for such decisions. A copy provided to GSFC within five business days of the conclusion of the meeting. GSFC shall retain the right to overturn decisions involving non-conformances within ten days after receipt of meeting minutes.

10.2.4 Part Approval Requests

Developer or subcontractor PCB members who are presenting part approval requests to the PCB shall provide part approval documentation as necessary to describe testing, screening, application and derating. Preparation of Nonstandard Parts Approval Requests (NSPARs) is not required. Parts previously approved by GSFC for the developer or subcontractor(s) via a NSPAR or by other means may be submitted to the PCB as an aid in documenting a specific need or application but does not constitute automatic approval for use in the STP application.

10.3 PARTS REQUIREMENTS

10.3.1 EEE Parts Selection

All parts shall be selected in accordance with GSFC 311-INST-001, "Instructions for EEE Parts Selection, Screening, and Qualification" for quality level 2. All part commodities identified in the GSFC 311-INST-001 are considered EEE parts and will be subjected to the requirements set forth in this section.

As an aid in selecting parts for STP, the following items are listed from 311-INST-001 and are tailored to STP needs. Parts selected and procured as specified below are considered acceptable by the STP Project at GSFC.

10.3.1.1 General

Parts listed in the GSFC Preferred Parts List (PPL), NASA Part Selection List (NPSL), or the NASA Standard Electrical, Electronic, and Electromechanical (EEE) Parts List (MIL-STD-975). Where differences in requirements exist between the PPL, NSPL and MIL-STD-975, the PPL shall take precedence. Parts should be procured in accordance with the appropriate specification designated for that part type, and shall be subjected to any required additional testing prior to use.

10.3.1.2 Microcircuits and Hybrids

MIL-PRF-38535 - Class Q or better, MIL-M-38510 - Class B or better microcircuits procured from a Qualified Manufacturers' List (QML) supplier. Additional PIND testing is required for class B and Q devices. Additional DPA is required for devices which did not receive precap visual inspection.

MIL-PRF-38534, Class H or better hybrid microcircuits procured from a Qualified Manufacturers' List (QML) supplier. Additional PIND testing and DPA are required for class H devices.

Standard Military Drawing (SMD) - Class M microcircuits that are not listed as QML sourced in MIL-HDBK-103 and are procured from an authorized supplier as listed in the SMD. Class M microcircuits procured to SMD's shall be subjected to additional PIND testing and DPA. Screening data is required with the order.

Microcircuits compliant with paragraph 1.2.1 of MIL-STD-883 and procured from manufacturers having QML status for parts of the same technology: Parts procured from manufacturers without QPL or QML status shall be procured with lot specific or generic Group C Quality Conformance Inspection (QCI) data within one year of the lot date code of the parts being procured. MIL-STD-883 compliant microcircuits shall be subjected to PIND testing. Screening data is required with the order. Precap visual inspection is recommended for hybrids.

Microcircuits and Hybrids processed to manufacturer's in-house high reliability flow, provided all screening tests listed in GSFC 311-INST-001 have been satisfied. The manufacturer should formally document the high reliability process flow. Additional tests not included in the manufacturer's high reliability flow must be performed by the manufacturer, an independent test facility, or by the developer, unless waived by the PCB. Parts procured in this section shall be procured with lot specific or generic Group C Quality Conformance Inspection (QCI) data within one year of the lot date code of the parts being procured. If not included in the manufacturer's high reliability test flow, the parts shall be subjected to PIND testing. A DPA may also be required for vendors that do not have a history of supplying reliable flight product. Screening data is required with the order. Precap visual inspection is recommended for hybrids.

10.3.1.3 Semiconductors

MIL-S-19500, JANTX, JANTXV and JANS semiconductors procured from a QPL listed supplier. Semiconductors procured to JANTXV level or better are preferred. Any JANTX and JANTXV semiconductor that has an internal

cavity shall be subjected to PIND testing in accordance with section 5.3.5.4. For JANTX level devices, a DPA on samples shall be performed.

10.3.1.4 Passive Parts

Established Reliability (ER) passive components procured from a QPL listed supplier for the appropriate military specification. Only ER parts within the minimum and maximum value ranges specified in the PPL shall be considered acceptable. Additional screening as required by GSFC 311-INST-001 and section 5.3.5 shall be performed.

10.3.1.5 Specification Drawings, all commodities

Parts procured to a GSFC S311 specification or from a GSFC approved source. For developer Controlled Drawings (SCD's, SID's, etc) see 5.3.2 below.

10.3.2 Developer Controlled Drawings

A developer controlled drawing may be necessary for procurement of parts where additional testing is required. These specifications shall fully identify the item being procured and shall include physical configuration, materials, environmental, electrical, and quality assurance provisions necessary to control manufacture and acceptance. Drawings shall specify test conditions, failure criteria, and lot rejection criteria. For lot acceptance or rejection, the Percentage of Defectives Allowable (PDA) in a screened lot shall be in accordance with that required in the closest military part specification.

10.3.3 Custom Devices

Custom microcircuits, hybrid microcircuits, MCM's, ASIC's, etc., planned for use by the developer shall be subjected to a design review. The review may be conducted as part of the PCB activity. The design review shall address element analysis, reliability, assembly process and materials, and method for assuring adequate thermal matching of materials. Also, all custom devices shall be subjected to a developer pre-cap inspection, or a GSFC approved inspector.

10.3.4 Off the Shelf Items

10.3.4.1 Plastic Encapsulated Microcircuits (PEMs).

The use of plastic microcircuits shall be restricted to applications where no similar high reliability hermetically sealed device exists. Each lot of plastic microcircuits shall be qualified by subjecting samples to Highly Accelerated Stress Testing (HAST; refer to 10.3.5.5) or Steady State Temperature Humidity Bias Life testing in order to qualify and assess overall package integrity of the lot.

10.3.4.2 Units and sub-assemblies.

Function of units or assemblies that are purchased as "off the shelf" hardware items shall be analyzed for mission criticality. When loss of off the shelf units does not compromise mission success, on a case-by-case basis, these units may be considered exempt from the parts control requirements of this section, subject to approval of the program office and the parts control board. However, the PCB or GSFC Project Office may direct additional unit level testing such as thermal cycling or thermal vacuum testing in lieu of additional part level screening.

When failure of such units represents significant compromise to mission success, an analysis of the parts used within the units shall be performed. The parts shall be evaluated for screening compliance to GSFC 311-INST-001, established reliability level, and include a radiation analysis. (A reliability analysis for proper derating, etc, is documented in section 7.0 of this MAR.) Pending the results of this investigation, units may be required to undergo modification for use of higher reliability parts, or Rad hard parts. All upgrade parts shall be subject to PCB approval. Modifications such as additional shielding for radiation effectiveness or replacing radiation soft parts for Rad-Hard parts, may be recommended and may be performed at the user's facility.

10.3.5 Screening and Testing

All parts used in the spacecraft and instruments shall be screened in accordance with GSFC 311-INST-001, "Instructions for EEE Parts Selection, Screening, and Qualification", for Parts Quality Level 2. Many standard items chosen from the GSFC PPL-21, NPSL or MIL-STD-975 may be used as is without further screening. However, when these standard items are selected and their normal screening does not meet the screening requirements of 311-INST-001, additional screening must be performed to bring them up to compliance with 311-INST-001 prior to use. Items not covered by the GSFC PPL or 311-INST-001, (ex: switches) shall be screened in accordance with the nearest applicable GSFC specification or military specification.

10.3.5.1 Parts Data and Test Sample Retention

The developer shall have a method in place for retention of data generated for parts tested and used in flight hardware, in order to facilitate future risk assessment and technical evaluation, as needed. In addition, the developer shall retain all part functional failures, all destructive and non-flight non-destructive test samples, which could be used for future validation of parts for performance under certain conditions not previously accounted for. PIND test failures do not require retention and may be submitted for DPA, radiation testing or used in engineering models. Parts and data shall be retained for the useful life of the spacecraft, unless otherwise approved by the PCB.

10.3.5.2 Verification Testing

10.3.5.2.1 Re-testing

When deemed necessary by age, failure history, GIDEP Alerts, or other reliability concerns, verification of performance by re-testing may be required. If required, testing shall be as determined by the PCB, based on the guidelines of GSFC 311-INST-001.

10.3.5.2.2 Screening Data

For non-QML, class M and 883 compliant microcircuits and hybrids, and non-QML semiconductor devices, screening data shall be procured with the order.

10.3.5.2.3 Plastic Encapsulated Microcircuits (PEMs)

All PEMs shall be subjected to screening to eliminate random early life failures. Screening shall consist of temperature cycling, burn-in, G-SAM (C-Mode Scanning Acoustic Microscopy; refer to 5.3.5.5.3) and electrical measurements.

A method of performing burn-in testing shall be developed based on manufacturer input. The ambient temperature, bias and duration of these tests shall be selected to result in a junction temperature that will adequately stress the devices in order to fail weak devices without impacting longevity of healthy devices. Tests and rationale shall be documented in the PCB minutes. Temperature cycling and burn-in shall be performed in dry nitrogen atmospheres to prevent moisture absorption during testing.

Where it can be demonstrated that manufacturers can produce reliable product such that screening would result in no early failures, burn-in can be waived and shall be documented by the PCB.

10.3.5.2.4 Field Programmable (non-erasable) devices.

For field programmable devices such as fuse linked PROMS, burn-in and final electricals shall be performed after programming. Burn in shall be performed for 160 hours at 125°C.

10.3.5.2.5 Magnetics

Magnetic devices (transformers and inductors) shall be assembled and screened to the requirements of MIL-STD-981 (Design, Manufacturing and Quality Standards for Custom Electromagnetic Devices for Space Applications) for class B devices. Burn-in screening shall be considered based on vendor history, performance stability requirements, device complexity, and application criticality.

10.3.5.2.6 Capacitors

Ceramics For 50V rated ceramic capacitors used in application voltages less than 10V DC, Steady State Humidity Low Voltage testing on 12 samples is required in accordance with MIL-PRF-123, group B inspection.

Tantalums For Tantalum capacitors, 100% surge current testing is required in accordance with the procedures in MIL-PRF-39003/10 for leaded capacitors or MIL-PRF-55365/4 for chip capacitors.

10.3.5.3 Destructive Physical Analysis

On the spacecraft bus and instruments, DPA procedures, sample size and criteria shall be performed per GSFC specification S-311-M-70, Destructive Physical Analysis. For small procurements, small lot sampling per 311-M-70 may be used. Developer's procedures for DPA may be used in place of S-311-M-70, if approved by the PCB prior to use. The PCB on a case-by-case basis shall consider variation to the DPA sample size requirements, due to quantity used in flight, application criticality, part complexity, availability or cost.

10.3.5.3.1 Microcircuits, Hybrids, Crystal Oscillators and Semiconductor Devices

For non-QML microcircuits and crystal oscillators, class H or equivalent hybrid microcircuits, and devices which did not receive customer internal visual inspection, a Destructive Physical Analysis (DPA) is required on samples of each lot date code. A DPA is also required for semiconductor devices that did not receive precap visual inspection. For small procurements, small lot sampling per 311-M-70 may be used.

10.3.5.3.2 Relays

For relays that were not subjected to small particle (millipore) cleaning and internal visual inspection (specified in the purchase order), a DPA shall be performed.

10.3.5.3.3 Other parts

Other part types may require a sample DPA as part of normal testing, or as dictated by failure from additional testing, or deemed necessary by failure history, GIDEP Alerts, or other reliability concerns.

10.3.5.4 Particle Impact Noise Detection (PIND)

10.3.5.4.1 Semiconductor Devices, Microcircuits and Hybrids

All devices with internal cavities shall be subjected to 100% PIND screening, in accordance with MIL-STD-883 or MIL-STD-750 as applicable. Any device failing this screen shall not be used in any flight application. Parts from lots exceeding 25% PIND failure, must be reviewed by the PCB for approval. PIND screening is not required for diodes with "double-plug" type construction.

10.3.5.4.2 Relays

Relay screening shall include PIND testing. Testing performed by the manufacturer is recommended, as they may be better equipped to perform this test than independent test labs.

10.3.5.5 Lot Qualification of PEMs

When plastic microcircuits are used, lot qualification shall be accomplished by subjecting samples from each lot to solder conditions, followed by Highly Accelerated Stress Testing (HAST) per 5.3.5.5.1 or Steady State Temperature Humidity Bias Life Test per 5.3.5.5.2, followed by analysis for package and performance degradation. Samples shall be taken from lots that have passed screening inspection. (See 5.3.5.2.3) These tests shall not be used as a substitution for 100% screening intended to remove random early life failures unless otherwise approved by the PCB.

In applications where lot specific data can be obtained from the manufacturer via the procurement cycle or via the manufacturer's web site, acceptable results may be accepted in lieu of performing certain tests. The PCB shall approve use of generic test data to satisfy this requirement. Qualification test requirements may be altered based on availability of data from the vendor, history of successful use of a vendor's product, the complexity of the device and application criticality. The PCB shall approve such changes to qualification.

For guidance, the following Lot Qualification procedure for PEMs is suggested. A developer controlled process approved by the PCB may also be used:

Perform pre-test DPA on 3 samples per date code.

Precondition samples (Reference JEDEC Standard JESD22-A113.) The following test preconditioning details shall apply:

Stabilization Bake at 125°C for 24 hours (or as altered by the PCB)

Moisture soak 85°C and 85% Relative Humidity for 168 hours (or as altered by the PCB)

Reflow solder, 220°C, 3 cycles

Flux immersion

Deionized water rinse

Perform Highly Accelerated Temperature and Humidity Stress Test (HAST) per 5.3.5.5.1 or Steady State Temperature Humidity Bias Life Test in accordance with 5.3.5.5.2.

Following the completion of HAST or Steady State Humidity testing perform the following examinations:

C-SAM (C-Mode Scanning Acoustic Microscopy) per 5.3.5.5.3

Electrical / functional testing at 25°C

Perform post-test DPA (3 samples per date code)

Highly Accelerated Stress Testing (HAST)

Testing shall be performed per JEDEC standard JESD22-A110. The following details shall apply:

Number of samples: 30 (Or as negotiated with the PCB)

Test temperature: 130°C (Or 110°C)

Test duration: 96 hours (264 hours when 110°C is used)

Pressure: 2X atmosphere

Relative humidity of 85%

Bias as required for the device type

Steady State Temperature Humidity Bias Life Testing

Testing shall be performed per JEDEC standard JESD22-A101. The following details shall apply:

Number of samples: 30 (Or as negotiated with the PCB)

Test temperature: 85°C

Test duration: 1000 hours

Pressure: room atmosphere

Relative humidity of 85%

Bias as required for the device type

C-SAM (C-Mode Scanning Acoustic Microscopy)

Perform C-SAM inspection per IPC/JEDEC J-STD-035. The Post reflow test failure criteria listed in section 8 of IPC/JEDEC J-STD-020 (Moisture/Reflow Sensitivity Classification for Non-hermetic Solid State Surface Mount Devices) is recommended. Another failure criteria may be used that is acceptable to the PCB.

10.3.6 Derating

All EEE parts shall be derated in accordance with the guidelines of GSFC PPL-21, appx B. The developer's derating policy may be used in place of the PPL guidelines and shall be submitted with the developers Parts Control

Plan (PCP) for approval. The developer shall maintain documentation on parts derating analysis and keep it available for GSFC review.

10.3.7 Radiation Hardness

All parts shall be selected to meet their intended application in the predicted mission radiation environment, and shall be reviewed for approval by the GSFC Radiation and Effects group. The radiation environment consists of two separate effects, those of Total Ionizing Dose (TID) and Single Event Effects (SEE). The developer shall document the analysis for each part with respect to both effects.

10.3.8 Parts Age Control

Parts drawn from inventory having lot-date-code (LDC) 9601 or older, shall be subjected to a room temperature re-screen and sample DPA as necessary per PCB recommendation. When parts can be traced to controlled storage conditions (in dry atmosphere at room temperature), or where the developer has a reliable history of old date code usage from certain vendors, this date code cutoff may be extended from date of receipt as permitted by the PCB. Parts with LDC prior to 9101, or stored in other than controlled conditions where they are exposed to the uncontrolled environments or sources of contamination, shall not be used.

10.3.9 One lot/One date code

Procurements of parts from one lot date/one date code are preferred but not required for STP.

10.4 TRACEABILITY CONTROL FOR PARTS

The developer shall maintain traceability records for all parts through incoming receiving inspection to board installation. Replacement control traceability shall also be kept for all removed parts, in order to allow for feedback on circuit performance as necessary. Records shall be kept on file for the useful life of the spacecraft.

10.4.1 Part Serial Numbers.

When serialized parts are used in flight hardware, part serial number shall be traceable to board installation location by circuit designator. (Ex: DRAM P/N 23456-7, S/N 101, installed on board 34567-501, S/N 201, microcircuit designator U10).

10.5 PARTS LISTS

The developer shall create and maintain a Parts Identification List (PIL) and Project Approved Parts List (PAPL) for the duration of the program. The developer may choose to incorporate the PIL into the PAPL for the creation of one list. Parts must be approved for listing on the PAPL prior to initiation of procurement activity. All PAPL submissions to the STP Project shall include a computer compatible form.

10.5.1 Parts Identification List (PIL)

The Parts Identification List (PIL) shall consist of all the candidate parts planned for use in flight hardware, and shall be developed concurrently with the design activity. The PIL shall be submitted for PCB approval prior to final design and start of procurement. The PIL normally shall include as a minimum the following information: part number, part name or description, manufacturer and/or manufacturer's generic part number, drawing number, specifications, quantities and notes as required to document application concerns, etc. The initial PIL and subsequent updates shall be submitted and reviewed with GSFC parts engineering.

10.5.2 Project Approved Parts List (PAPL)

The Project Approved Parts List (PAPL) shall contain all approved parts for flight hardware. Traceability to box level use is recommended. Only parts that have been evaluated and approved by the PCB shall be listed in the PAPL.

10.5.3 As-Built-Parts List (ABPL)

An As-Built Parts List (ABPL) shall also be prepared and submitted to GSFC parts engineering. The ABPL is generally a final compilation of all parts as installed in flight equipment, with additional as-installed information such as manufacturer name, CAGE code, Lot-Date Code, quantity used and board location. The manufacturer's plant specific CAGE code is preferred, but if unknown, the supplier's general cage code is sufficient to meet this requirement. (For example the Texas Instruments general cage code 01295 may be used if specific plant is unknown.)

10.6 ALERTS

The developer shall be responsible for the review and disposition of all Government Industry Data Exchange Program (GIDEP) Alerts for impact on flight equipment. New parts procurements and parts pulled from storage shall be continuously checked for impact. Parts pulled from inventory for flight shall have the alert history checked for the period dating back to the date code marked on the parts. In addition, any NASA Alerts and Advisories provided to the developer by GSFC shall be reviewed and dispositioned. Alert applicability, impact, and corrective actions shall be documented and made available to GSFC review.

In the event of a conflict between GIDEP alerts and NASA Advisories, the NASA Advisory shall govern.

Chapter 11. MATERIALS, PROCESSES, AND LUBRICATION REQUIREMENTS

11.0 GENERAL REQUIREMENTS

The developer shall implement comprehensive Materials, Processes, and Lubrication (M&P) Program beginning at the design stage of the hardware for each STP Observatory. The program shall include a comprehensive Materials and Processes Plan in accordance with the CDRL. The Materials and Processes Plan shall include the control of magnetics. The program shall help ensure the success and safety of the mission by the appropriate selection, processing, inspection, and testing of the materials (including lubricants) employed to meet the operational requirements. Materials, processing, and lubrication assurance information is required for each usage or application.

The developer shall maintain communications on a regular basis with the GSFC Materials Assurance Engineer to ensure there is adequate materials usage information to approve each materials usage or application on STP. The developer shall maintain lists of these items (inorganics and metallics, polymeric, lubricants, and processes) and appropriate usage records. The equivalent GSFC forms 18-59A, B, C, and D define information considered important. The list(s) shall be maintained in a computer compatible form.

The materials list can be just one list that includes the lubrication, polymeric, and inorganic materials along with a list of the processes expected for use. This list shall be available to GSFC upon request and shall be presented at the PDR and CDR.

An as-built materials and processes list shall be submitted as part of the Acceptance Data Package.

11.1 MATERIALS SELECTION REQUIREMENTS

In order to anticipate and minimize materials problems during space hardware development and operation, the developer shall, when selecting materials and lubricants, consider the following potential problem areas: radiation effects, thermal cycling, stress corrosion cracking, galvanic corrosion, hydrogen embrittlement, lubrication, contamination of cooled surfaces, composite materials, atomic oxygen, useful life, vacuum outgassing, flammability and fracture toughness as well as the properties required by each material usage or application.

11.1.1 Compliant Materials

The developer shall use compliant materials in the fabrication of flight hardware to the extent practicable. In order to be compliant, a material must be used in a conventional application and meet the ELV criteria identified in Table 11.1.

11.1.2 Noncompliant Materials

A material that does not meet the ELV requirements of Table 11.1, or meets the ELV requirements of Table 11.1 but is used in an unconventional application shall be considered to be a noncompliant material. The developer shall provide an open loop of communication for the GSFC Materials Assurance Engineer to assess and recommend approval of the noncompliant materials. The proposed use of a non-compliant material requires that a Materials Usage Agreement (MUA) and/or a Stress Corrosion Evaluation Form (see Figures 11-1a and 11-1b) or a subcontractor's equivalent form be submitted to the GSFC STP Project for concurrence in accordance with the CDRL.

11.1.3 Materials Used in "Off-the-Shelf-Hardware"

"Off-the-shelf hardware" for which a detailed materials list is not available and where the included materials cannot be easily identified and/or changed shall be treated as noncompliant. The developer shall define (on a MUA) what measures will be used to ensure that all materials in the hardware are acceptable for use. Such measures might include any one, or a combination, of the following: hermetic sealing, vacuum bakeout, material changes for known noncompliant materials, etc. When a vacuum bakeout is the selected method, it must incorporate a quartz crystal microbalance (QCM) and cold finger to enable a determination of the duration and effectiveness of the bakeout as well as compliance with the instrument contamination plan.

11.1.4 Conventional Applications

Conventional applications or usage of materials is the use of compliant materials in a manner for which there is extensive satisfactory aerospace heritage.

11.1.5 Nonconventional Applications

The proposed use of a compliant material for an application for which there is limited satisfactory aerospace usage shall be considered a nonconventional application. In that case, the material usage shall be verified for the desired application on the basis of test, similarity, analyses, inspection, existing data, or a combination of those methods. This information shall be provided to the GSFC Material Assurance Engineer during design reviews or other project meetings. The proposed use of a material in a nonconventional application requires that a MUA and/or Nonconventional Material and Lubricant Report be submitted to the GSFC STP Project for concurrence. See Figure 11-1 for a sample MUA form. The developer's equivalent form may be used.

11.1.6 Polymeric Materials

The developer shall document a polymeric materials and composites usage list per Figure 11-2, or the developer's equivalent form. Material acceptability shall be determined on the basis of flammability, vacuum outgassing and all other materials properties relative to the application requirements and usage environment. The polymeric material list shall be included as part of the as-designed list submitted by the developer. A separate list is not required.

11.1.6.1 Flammability and Toxicity

Expendable Launch Vehicle (ELV) payload materials shall meet the requirements of EWR 127-1 "Eastern and Western Range Safety Requirements" for usage of hazardous materials (Sections 3.10 and 3.12).

TABLE 11-1
MATERIAL SELECTION CRITERIA

Type	Payload	Flammability	and	Vacuum	Stress Corrosion
Launch	Location	Toxicity		Outgassing	Cracking (SCC)
ELV	All	Note 1		Note 2	Note 3

NOTES:

- 1. Hazardous materials requirements including flammability, toxicity, and compatibility as specified in EWR 127-1 (Sections 3.10 and 3.12).*
- 2. Vacuum Outgassing requirements as defined in paragraph 11.1.6.2.*
- 3. Stress corrosion cracking requirements as defined in MSFC-SPEC-522.*

11.1.6.2 Vacuum Outgassing

Material vacuum outgassing shall be determined in accordance with ASTM E595. A material is qualified on a product-by-product basis. GSFC may require lot testing of any material for which lot variation is suspected. In such cases, material approval is contingent upon lot testing. Only materials that have a total mass loss (TML) <1.00% and a collected volatile condensable mass (CVCM) <0.10% will be approved for use in a vacuum environment unless application considerations (listed on a MUA) are submitted and granted by the STP project. The overall mission contamination control requirements may demand more stringent outgassing criteria.

11.1.6.3 Shelf-Life-Controlled Materials

Polymeric materials that have a limited shelf-life shall be controlled by a program that identifies the start date (manufacturer's processing, shipment date, or date of receipt, etc.), the storage conditions associated with a specified shelf-life, and expiration date. Materials such as o-rings, rubber seals, tape, uncured polymers, lubricated bearings and paints shall be included. The use of materials whose date code has expired requires that the developer demonstrate by means of appropriate tests that the properties of the materials have not been compromised for their intended use; such materials must be approved by the STP project by means of a waiver. All limited-life items, including piece parts in subassemblies, shall be included in the Limited-Life list (see paragraph 7.2) as part of the Acceptance Data Package.

11.1.7 Inorganic Materials

The developer shall document an inorganic materials and composites usage list per Figure 11-3 or the developer's equivalent form including supporting applications data. The criteria specified in MSFC-SPEC-522 shall be used to determine that metallic materials meet the stress corrosion cracking criteria. A MUA and stress corrosion cracking evaluation form shall be submitted by the developer for each material usage that does not comply with the MSFC-SPEC-522 stress corrosion cracking requirements. Timely developer discussions with the GSFC Materials Assurance Engineer are encouraged. Nondestructive evaluation requirements are contained in the ELV structure integrity requirements. The inorganic material list shall be included as part of the as-designed list submitted by the developer. A separate list is not required.

11.1.8 Fasteners

The developer shall comply with the procurement documentation and test requirements for flight hardware and critical ground support equipment fasteners contained in GSFC S-313-100, Goddard Space Flight Center Fastener Integrity Requirements. Fastener use shall be documented in accordance with the CDRL. Fasteners made of plain carbon or low alloy steel shall be protected from corrosion. When plating is specified, it shall be compatible with the space environment. On steels harder than RC 33, plating shall be applied by a process not embrittling to the steel.

11.1.9 Lubrication

The developer shall document (and submit to the GSFC STP Project materials engineer for review/approval) a lubrication usage list per Figure 11-4 or the developer's equivalent. When requested, the developer shall provide supporting applications data. Lubricants shall be selected for use on the basis of valid test results that confirm the suitability of the composition and the performance characteristics for each specific application, including compatibility with the anticipated environment and contamination effects. All lubricated mechanisms shall be qualified by life testing in accordance with a life test plan or heritage of an identical mechanism used in identical applications in accordance with the CDRL.

11.1.10 Magnetic Sensitivity

The measured magnetic field contribution from the spacecraft at the science magnetometer location shall be less than 1 nT (static) and 0.05 nT (dynamic). A Magnetics Compatibility Plan shall be developed in accordance with the guidelines in the document GSFC-695-xxx "The Design, Construction and Test of Magnetically Clean Spacecraft - A Practical Guide".

11.2 PROCESS SELECTION REQUIREMENTS

The developer shall prepare (and submit to GSFC for review/approval) a material process utilization list per Figure 11-5 or the developer's equivalent. When requested, a copy of any process shall be made available to GSFC. Manufacturing processes (e.g., lubrication, heat treatment, welding, chemical or metallic coatings) shall be carefully selected to prevent any unacceptable material property changes that could cause adverse effects of materials applications.

11.3 PROCUREMENT REQUIREMENTS

11.3.1 Purchased Raw Materials

The results of nondestructive, chemical and physical tests, or a Certificate of Compliance shall accompany raw materials purchased by the developer.

11.3.2 Raw Materials Used in Purchased Products

The developer shall require that the suppliers meet the requirements of 6.4.1 and provide on request the results of acceptance tests and analyses performed on raw materials or a Certificate of Compliance.

11.4 GIDEP ALERTS

The developer shall keep materials selection and usage records sufficient to determine applicability of any Government Industry Data Exchange Program (GIDEP) alerts related to materials used for STP.

MATERIAL USAGE AGREEMENT				USAGE AGREEMENT NO.:		PAGE OF	
PROJECT:		SUBSYSTEM:		ORIGINATOR:			ORGANIZATION :
DETAIL DRAWING		NOMENCLATURE		USING ASSEMBLY		NOMENCLATURE	
MATERIAL & SPECIFICATION				MANUFACTURER & TRADE NAME			
USAGE	THICKNESS	WEIGHT	EXPOSED AREA	ENVIRONMENT			
				PRESSURE	TEMPERATURE	MEDIA	
APPLICATION:							
RATIONALE:							
ORIGINATOR:			PROJECT MANAGER:			DATE:	

FIGURE 11-1 MUA

FIGURE 11-2: STRESS CORROSION EVALUATION FORM

1. Part Number _____
2. Part Name _____
3. Next Assembly Number _____
4. Manufacturer _____
5. Material _____
6. Heat Treatment _____
7. Size and Form _____
8. Sustained Tensile Stresses-Magnitude and Direction
 - a. Process Residual _____
 - b. Assembly _____
 - c. Design, Static _____
9. Special Processing _____
10. Weldments
 - a. Alloy Form, Temper of Parent Metal _____
 - b. Filler Alloy, if none, indicate _____
 - c. Welding Process _____
 - d. Weld Bead Removed - Yes (), No () _____
 - e. Post-Weld Thermal Treatment _____
 - f. Post-Weld Stress Relief _____
11. Environment _____
12. Protective Finish _____
13. Function of Part _____
14. Effect of Failure _____
15. Evaluation of Stress Corrosion Susceptibility _____
16. Remarks: _____

POLYMERIC MATERIALS AND COMPOSITES USAGE LIST								
SPACECRAFT _____		SYSTEM/EXPERIMENT _____		GSFC T/O _____				
DEVELOPER/DEVELOPER _____		ADDRESS _____						
PREPARED BY _____		PHONE _____		DATE _____		PREPARED _____		
				DATE _____		DATE _____		
GSFC MATERIALS EVALUATOR _____		PHONE _____		RECEIVED _____		EVALUATED _____		

ITEM NO.	MATERIAL IDENTIFICATION ⁽²⁾	MIX FORMULA ⁽³⁾	CURE ⁽⁴⁾	AMOUNT CODE	EXPECTED ENVIRONMENT ⁽⁵⁾	REASON FOR SELECTION ⁽⁶⁾	OUTGASSING VALUES	
							TML	CVCM
<p>NOTES</p> <ol style="list-style-type: none"> 1. List all polymeric materials and composites applications utilized in the system except lubricants which should be listed on polymeric and composite materials usage list. 2. Give the name of the material, identifying number and manufacturer. Example: Epoxy, Epon 828, E. V. Roberts and Associates 3. Provide proportions and name of resin, hardener (catalyst), filler, etc. Example: 828/V140/Silflake 135 as 5/5/38 by weight 4. Provide cure cycle details. Example: 8 hrs. at room temperature + 2 hrs. at 150C 5. Provide the details of the environment that the material will experience as a finished S/C component, both in ground test and in space. List all materials with the same environment in a group. Example: T/V : -20C/+60C, 2 weeks, 10E-5 torr, ultraviolet radiation (UV) <div style="margin-left: 20px;">Storage: up to 1 year at room temperature</div> <div style="margin-left: 20px;">Space: -10C/+20C, 2 years, 150 mile altitude, UV, electron, proton, atomic oxygen</div> 6. Provide any special reason why the materials was selected. If for a particular property, please give the property. Example: Cost, availability, room temperature curing or low thermal expansion. 								

INORGANIC MATERIALS AND COMPOSITES USAGE LIST							
SPACECRAFT _____		SYSTEM/EXPERIMENT _____		GSFC T/O _____			
DEVELOPER/DEVELOPER _____		ADDRESS _____					
PREPARED BY _____		PHONE _____		DATE _____		PREPARED _____	
				DATE _____		DATE _____	
GSFC MATERIALS EVALUATOR _____		PHONE _____		RECEIVED _____		EVALUATED _____	

ITEM NO.	MATERIAL IDENTIFICATION ⁽²⁾	CONDITION ⁽³⁾	APPLICATION ⁽⁴⁾ OR OTHER SPEC. NO.	EXPECTED ENVIRONMENT ⁽⁵⁾	S.C.C. TABLE NO.	MUA NO.	NDE METHOD
<p>NOTES:</p> <ol style="list-style-type: none"> 1. List all inorganic materials (metals, ceramics, glasses, liquids, and metal/ceramic composites) except bearing and lubrication materials that should be listed on Form 18-59C. 2. Give materials name , identifying number manufacturer. Example: a. Aluminum 6061-T6 b. Electroless nickel plate, Enplate Ni 410, Enthone, Inc. c. Fused silica, Corning 7940, Corning Class Works 3. Give details of the finished condition of the material, heat treat designation (hardness or strength), surface finish and coating, cold worked state, welding, brazing, etc. Example: a. Heat treated to Rockwell C 60 hardness, gold electroplated, brazed. B. Surface coated with vapor deposited aluminum and magnesium fluoride c. Cold worked to full hare condition, TIG welded and electroless nickel plated. 4. Give details of where on the spacecraft the material will be used (component) and its function. Example: Electronics box structure in attitude control system, not hermetically sealed. 5. Give the details of the environment that the material will experience as a finished S/C component, both in ground test and in space. Exclude vibration environment. List all materials with the same environment in a group. Example: T/V: -20C/+60C, 2 weeks, 10E-5 torr, Ultraviolet radiation (UV) Storage: up to 1 year at room temperature Space: -10C/+20C, 2 years, 150 miles altitude, UV, electron, proton, Atomic Oxygen 							

GSFC 18-59A 3/78

FIGURE 11-4 INORGANIC MATERIALS AND COMPOSITES USAGE LIST

LUBRICATION USAGE LIST							
SPACECRAFT _____		SYSTEM/EXPERIMENT _____			GSFC T/O _____		
DEVELOPED/DEVELOPER _____		ADDRESS _____					
PREPARED BY _____		PHONE _____			DATE _____		
					PREPARED _____		
					DATE _____		
GSFC MATERIALS EVALUATOR _____		PHONE _____			RECEIVED _____		EVALUATED _____

ITEM NO.	COMPONENT TYPE, SIZE MATERIAL ⁽¹⁾	COMPONENT MANUFACTURER & MFR. IDENTIFICATION	PROPOSED LUBRICATION SYSTEM & AMT. OF LUBRICANT	TYPE & NO. OF WEAR CYCLES ⁽²⁾	SPEED, TEMP., ATM. OF OPERATION ⁽³⁾	TYPE OF LOADS & AMT.	OTHER DETAILS ⁽⁵⁾
<p>NOTES</p> <p>(1) BB = ball bearing, SB = sleeve bearing, G = gear, SS = sliding surfaces, SEC = sliding electrical contacts. Give generic identification of materials used for the component, e.g., 440C steel, PTFE.</p> <p>(2) CUR = continuous unidirectional rotation, CO = continuous oscillation, IR = intermittent rotation, IO = intermittent oscillation, SO = small oscillation, (<30°), LO = large oscillation (>30°), CS = continuous sliding, IS = intermittent sliding. No. of wear cycles: A(1-10²), B(10²-10⁴), C(10⁴-10⁶), D(>10⁶)</p> <p>(3) Speed: RPM = revs./min., OPM = oscillations/min., VS = variable speed CPM = cm/min. (sliding applications). Temp. of operation, max. & min., °C Atmosphere: vacuum, air, gas, sealed or unsealed & pressure</p> <p>(4) Type of loads: A = axial, R = radial, T = tangential (gear load). Give amount of load.</p> <p>(5) If BB, give type and material of ball cage and number of shields and specified ball groove and ball finishes. If G, give surface treatment and hardness. If SB, give dia. of bore and width. If torque available is limited, give approx. value.</p>							

GSFC 18-59C 3/78

FIGURE 11-5 LUBRICATION USAGE LIST

MATERIALS PROCESS UTILIZATION LIST					
SPACECRAFT _____		SYSTEM/EXPERIMENT _____		GSFC T/O _____	
DEVELOPER/DEVELOPER _____		ADDRESS _____			
PREPARED BY _____		PHONE _____		DATE PREPARED _____	
GSFC MATERIALS EVALUATOR _____		PHONE _____		DATE RECEIVED _____ DATE EVALUATED _____	

ITEM NO.	PROCESS TYPE ⁽¹⁾	DEVELOPER SPEC. NO. ⁽²⁾	MIL., ASTM., FED. OR OTHER SPEC. NO.	DESCRIPTION OF MAT'L PROCESSED ⁽³⁾	SPACECRAFT/EXP. APPLICATION ⁽⁴⁾
<p>NOTES</p> <p>(1) Give generic name of process, e.g., anodizing (sulfuric acid).</p> <p>(2) If process is proprietary, please state so.</p> <p>(3) Identify the type and condition of the material subjected to the process. E.g., 6061-T6</p> <p>(4) Identify the component or structure of which the materials are being processed. e.g., Antenna dish</p>					

GSFC 18-59D 3/78

FIGURE 11-6 MATERIALS PROCESS UTILIZATION LIST

Chapter 12. Contamination Control Requirements

12.0 GENERAL REQUIREMENTS

The developer shall plan and implement a contamination control program for STP hardware. The developer shall establish the specific cleanliness requirements and delineate the approaches to meet the requirements in a Contamination Control Plan (CCP) deliverable to the GSFC Project for concurrence in accordance with the CDRL.

Contamination includes all materials of molecular and particulate nature whose presence degrades hardware performance. The source of the contaminant materials may be the hardware itself, the test facilities, and the environments to which the hardware is exposed.

12.1 CONTAMINATION CONTROL PLAN

The developer shall prepare a Contamination Control Plan (CCP) that describes the procedures that will be followed to control contamination. The CCP shall establish the implementation and describe the methods that will be used to measure and maintain the levels of cleanliness required during each of the various phases of the item's lifetime. In general, all mission hardware should be compatible with the most contamination-sensitive components. The contamination potential of material and equipment used in cleaning, handling, packaging, tent enclosures, shipping containers, bagging (e.g., anti-static film materials), and purging shall be described in detail for each subsystem or component at each phase of assembly, integration, test, and launch.

12.1.1 Contamination Control Verification Process

The developer shall develop a contamination control verification process as part of the CCP. The verification process shall be performed in order to allow the:

- a. Determination of contamination sensitivity;
- b. Determination of a contamination allowance;
- c. Determination of a contamination budget;
- d. Development and implementation of a contamination control plan.

12.2 MATERIAL OUTGASSING

All materials shall be screened in accordance with NASA Reference Publication 1124, Outgassing Data for Selecting Spacecraft Materials. Individual material outgassing data shall be established based on each component's operating conditions. Established material outgassing data shall be verified and shall be provided to GSFC for review.

12.3 THERMAL VACUUM BAKEOUT

The developer shall perform thermal vacuum bakeouts of all hardware as required to protect contamination-sensitive components. The parameters of such bakeouts (e.g., temperature, duration, outgassing requirements, and pressure) must be individualized depending on materials used, the fabrication environment, and the established contamination allowance. Thermal vacuum bakeout results shall be verified and shall be provided to GSFC for review.

A quartz crystal microbalance (QCM) or temperature controlled quartz crystal microbalance (TQCM) and cold finger shall be incorporated during all thermal vacuum bakeouts at the spacecraft level. These devices shall provide additional information to enable a determination of the duration and effectiveness of the thermal vacuum bakeout as well as compliance with the CCP.

Chapter 13. Electrostatic Discharge (ESD) Control

13.0 GENERAL REQUIREMENTS

The developer shall document and implement an ESD Control Program to assure that all manufacturing, inspection, testing, and other processes will not compromise mission objectives for quality and reliability due to ESD events.

13.1 APPLICABLE DOCUMENTS*

Electrostatic Discharge Control (ESD): ANSI/ESD S20.20, Protection of Electrical and Electronic Parts, Assemblies and Equipment (Excluding Electrically Initiated Explosive Devices)

*Current status and/or any application notes for these standards can be obtained at URL <http://standards.nasa.gov>

13.2 ELECTROSTATIC DISCHARGE CONTROL REQUIREMENTS

The developer shall document and implement an ESD Control Program in accordance with ANSI/ESD S20.20 suitable to protect the most sensitive component involved in the project. At a minimum, the ESD Control Program shall address training, protected work area procedures and verification schedules, packaging, facility maintenance, storage, and shipping.

All personnel who manufacture, inspect, test, otherwise process electronic hardware, or require unescorted access into ESD protected areas shall be certified as having completed the required training, appropriate to their involvement, as defined in ANSI/ESD S20.20 or in the developer's PAIP prior to handling any electronic hardware.

Electronic hardware shall be manufactured, inspected, tested, or otherwise processed only at designated ESD protective work areas. These work areas shall be verified on a regular schedule as identified in the developer's ESD Control Program.

Electronic hardware shall be properly packaged in ESD protective packaging at all times when not actively being manufactured, inspected, tested, or otherwise processed.

The developer may propose alternate standards. Their use is limited to the specific project and is allowed only after they have been reviewed and approved by the GSFC STP Project Office.

Chapter 14. GIDEP Alerts and Problem Advisories

14.0 GENERAL REQUIREMENTS

The developer shall participate in the Government-Industry Data Exchange Program (GIDEP) in accordance with the requirements of the GIDEP S0300- BT-PRO-010 and S0300-BU-GYD-010, available from the GIDEP Operations Center, PO Box 8000, Corona, California 91718-8000. The developer shall review all GIDEP ALERTS, GIDEP SAFE-ALERTS, GIDEP Problem Advisories, GIDEP Agency Action Notices, and NASA Advisories to determine if they affect the developer products produced for NASA. For GIDEP ALERTS, GIDEP SAFE-ALERTS, GIDEP Problem Advisories, GIDEP Agency Action Notices, and NASA Advisories that are determined to affect the program, the developer shall take action to eliminate or mitigate any negative effect to an acceptable level. The developer shall generate the appropriate failure experience data report(s) (GIDEP ALERT, GIDEP SAFE-ALERT, GIDEP Problem Advisory) in accordance with the requirements of GIDEP S0300-BT-PRO-010 and S0300-BU-GYD-010 whenever failed or nonconforming items, available to other buyers, are discovered during the course of the contract.

14.1 GIDEP ALERT RESPONSE

The developer shall review and disposition of all Government Industry Data Exchange Program (GIDEP) Alerts for impact on flight equipment. New parts procurements and parts pulled from storage shall be continuously checked for impact. Parts pulled from inventory for flight shall have the alert history checked for the period dating back to the date code marked on the parts. In addition, any NASA Alerts and Advisories provided to the developer by GSFC shall be reviewed and dispositioned. Alert applicability, impact, and corrective actions shall be documented and status provided to GSFC on a monthly basis.

In the event of a conflict between GIDEP alerts and NASA Advisories, the NASA Advisory shall govern.

Chapter 15. Applicable Documents List

<u>DOCUMENT</u>	<u>DOCUMENT TITLE</u>
ANSI/ASQC Q9001-2000	Model for Quality Assurance in Design, Development, Production, Installation, and Servicing
ANSI/IPC-A-600	Acceptance Criteria for Printed Wiring Boards
ANSI/J STD 001	Requirements for Soldered Electrical and Electronic Assemblies (not allowed for space flight hardware)
ASTM E-595	Total Mass Loss (TML) and Collected Volatile Condensable Materials (CVCM) from Outgassing in a Vacuum Environment
EWB 127-1	Eastern and Western Range Safety Requirements
GEVS-SE	General Environmental Verification Specification for STS & ELV Payloads, Subsystems, and Components, rev A, dated June 1996
GSFC 311-INST-001	Instructions for EEE Parts Selection, Screening, and Qualification
GSFC PPL	Goddard Space Flight Center Preferred Parts List
GSFC S-312-P003	Procurement Specification for Rigid Printed Boards for Space Applications and Other High Reliability Uses
GSFC S-313-100	Goddard Space Flight Center Fastener Integrity Requirements
MIL-STD 1629A	Procedures for Performing a Failure Mode Effects and Criticality Analysis
MSFC-HDBK-527	Material Selection List for Space Hardware Systems
MSFC-SPEC-522	Design Criteria for Controlling Stress Corrosion Cracking

NASA Reference Publication (RP) 1124	Outgassing Data for Selecting Spacecraft Materials
NASA RP-1161	Evaluation of Multi-layer Printed Wiring Boards by Metallographic Techniques
NASA-STD-8739.1	Workmanship Standard for Staking and Conformal Coating of Printed Wiring Boards and Electronics Assemblies (Replaces NAS 5300.4(3J-1))
NASA-STD-8739.2	NASA Workmanship Standard for Surface Mount Technology (Replaces NAS 5300.4(3M))
NASA STD 8739.3	Requirements for Soldered Electrical Connections Replaces NHB 5300.4(3A-2)
NASA STD 8739.4	Requirements for Crimping Inter-connecting Cables, Harnesses, and Wiring (Replaces NHB5300.4(3G))
NASA STD 8739.5	Fiber Optics Termination Standard
ANSI/ESD S20.20	Protection of Electrical and Electronic Parts, Assemblies and Equipment (Excluding Electrically Initiated Explosive Devices)
NHB 8060.1	Flammability, Odor, and Offgassing Requirements and Test Procedures for Materials in Environments That Support Combustion
NASA-STD-8713A	NASA Software Safety Standard
NSTS 22648	Flammability Configuration Analysis for Spacecraft Applications
S-302-89-01	Procedures for Performing a Failure Mode and Effects Analysis (FMEA)
S-311-M-70	Specification for Destructive Physical Analysis

Chapter 16. Acronyms and Glossary

16.0 ACRONYMS

ABPL	As-Built Parts List
ADPMPL	As-Designed Parts, Materials and Processes List
ANSI	American National Standards Institute
AR	Acceptance Review
ASIC	Application Specific Integrated Circuits
ASQ	American Society for Quality
BB	Ball Bearing
BOL	Beginning of Life
CCB	Configuration Control Board
CCP	Contamination Control Plan
CDR	Critical Design Review
CDRL	Contract Delivery Requirements List
CIL	Critical Items List
COTS	Commercial Off-The Shelf
CPT	Comprehensive Performance Test
CVCM	Collected Volatile Condensable Mass
DID	Data Item Description
DoD	Department of Defense
DPA	Destructive Physical Analysis
EEE	Electrical, Electronic, and Electromechanical
ELV	Expendable Launch Vehicle
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
ETM	Environmental Test Matrix
EOL	End of Life
FMEA	Failure Modes and Effects Analysis
FOR	Flight Operations Review
FRB	Failure Review Board
GEVS	General Environmental Verification Specification
GEVS-SE	General Environmental Verification Specification for STS & ELV Payloads, Subsystems, and Components
GFE	Government-Furnished Equipment

GIA	Government Inspection Agency
GIDEP	Government Industry Data Exchange Program
GMI	Goddard Management Instruction
GSE	Ground Support Equipment
GSFC	Goddard Space Flight Center
IAC	Independent Assurance Contractor
ICD	Interface Control Document
JPL	Jet Propulsion Laboratory
JSC	Johnson Space Center
LPT	Limited Performance Test
LRR	Launch Readiness Review
MAE	Materials Assurance Engineer
MCM	Multi-Chip Module
MO&DSD	Mission Operations and Data Systems Directorate
MOR	Mission Operations Review
MRB	Material Review Board
MSFC	Marshall Space Flight Center
MSR	Management Status Report
MUA	Materials Usage Agreement
NAS	NASA Assurance Standard
NASA	National Aeronautics and Space Administration
Nascom	NASA Communications Network
NHB	NASA Handbook
NPSL	NASA Parts Selection List
NSTS	National Space Transportation System
OSSMA	Office of Systems Safety and Mission Assurance
PAPL	Project Approved Parts List
PCB	Parts Control Board
PCP	Parts Control Plan
PDR	Preliminary Design Review
PE	Parts Engineer
PER	Pre-Environmental Review
PFR	Problem/Failure Report
PIL	Parts Identification List
PIND	Particle Impact Noise Detection
PMP	Parts, Materials and Processes

PMPCB	Parts, Materials and Processes Control Board
PMPCP	Parts, Materials and Processes Control Program
PMPSL	Parts, Materials and Processes Selection List
PPL	Preferred Parts List
PRA	Probabilistic Risk Assessment
PSR	Pre-Shipment Review
PWB	Printed Wiring Board
QCI	Quality Conformance Inspection
QCM	Quartz Crystal Microbalance
QML	Qualified Manufacturer's List
QPL	Qualified Parts List
RH	Relative Humidity
RHA	Radiation Hardness Assurance
SB	Sleeve Bearing
SCC	Stress Corrosion Cracking
SCD	Source Control Drawing
SCM	Software Configuration Management
SCR	System Concept Review
SOW	Statement of Work
SQMS	Software Quality Management System
SRO	Systems Review Office
SR&QA	Safety, Reliability and Quality Assurance
SRR	Software Requirements Review
STS	Space Transportation System (Shuttle)
TML	Total Mass Loss
TR	Torque Ratio
TRR	Test Readiness Review

16.1 DEFINITIONS

The following definitions apply within the context of this document:

Acceptance Test: The validation process that demonstrates that hardware is acceptable for flight. It also serves as a quality control screen to detect deficiencies and, normally, to provide the basis for delivery of an item under terms of a contract.

Assembly: See Level of Assembly.

Audit: A review of the developer's or subdeveloper's documentation or hardware to verify that it complies with project requirements.

Collected Volatile Condensable Material (CVCVM): The quantity of outgassed matter from a test specimen that condenses on a collector maintained at a specific constant temperature for a specified time.

Component: See Level of Assembly.

Comprehensive Performance Test: The operation of a unit in accordance with a defined operational procedure to verify that performance is compliant with all parameters of the specified requirements. CPTs are performed at major project milestones and serve as a quality control screen to detect deficiencies, establish performance baselines, identify subtle changes, and provide accumulated data for trending analyses.

Configuration: The functional and physical characteristics of the payload and all its integral parts, assemblies and systems that are capable of fulfilling the fit, form and functional requirements defined by performance specifications and engineering drawings.

Configuration Control: The systematic evaluation, coordination, and formal approval/disapproval of proposed changes and implementation of all approved changes to the design and production of an item the configuration of which has been formally approved by the developer or by the purchaser, or both.

Configuration Management: The systematic control and evaluation of all changes to baseline documentation and subsequent changes to that documentation which define the original scope of effort to be accomplished (contract and reference documentation) and the systematic control, identification, status accounting and verification of all configuration items.

Contamination: The presence of materials of molecular or particulate nature, which degrade the performance of hardware.

Critical: A potential failure effect which would result in a significant (as defined by the project) performance degradation of an item of hardware or a mission.

Derating: The reduction of the applied load (or rating) of a device to improve reliability or to permit operation at high ambient temperatures.

Designated Representative: An individual (such as a NASA plant representative), firm (such as assessment developer), Department of Defense (DOD) plant representative, or other government representative designated and authorized by NASA to perform a specific function for NASA. As related to the developer's effort, this may include evaluation, assessment, design review, participation, and review/approval of certain documents or actions.

Destructive Physical Analysis (DPA): An internal destructive examination of a finished part or device to assess design, workmanship, assembly, and any other processing associated with fabrication of the part.

Design Qualification Tests: Tests intended to demonstrate that the test item will function within performance specifications under simulated conditions more severe than those expected from ground handling, launch, and orbital operations. Their purpose is to uncover deficiencies in design and method of manufacture. They are not intended to exceed design safety margins or to introduce unrealistic modes of failure. The design qualification tests may be to either “prototype” or “protoflight” test levels.

Discrepancy: See Nonconformance

Electromagnetic Compatibility (EMC): The condition that prevails when various electronic devices are performing their functions according to design in a common electromagnetic environment.

Electromagnetic Interference (EMI): Electromagnetic energy, which interrupts, obstructs, or otherwise degrades or limits the effective performance of electrical equipment.

Electromagnetic Susceptibility: Undesired response by a component, subsystem, or system to conducted or radiated electromagnetic emissions.

End-to-End Tests: Tests performed on the integrated ground and flight system, including all elements of the payload, its control, stimulation, communications, and data processing to demonstrate that the entire system is operating in a manner to fulfill all mission requirements and objectives.

Failure: A departure from specification that is discovered in the functioning or operation of the hardware or software. See nonconformance.

Failure Modes and Effects Analysis (FMEA): A procedure by which each credible failure mode of each item from a low indenture level to the highest is analyzed to determine the effects on the system and to classify each potential failure mode in accordance with the severity of its effect.

Flight Acceptance: See Acceptance Tests.

Fracture Control Program: A systematic project activity to ensure that a payload intended for flight has sufficient structural integrity as to present no critical or catastrophic hazard. Also to ensure quality of performance in the structural area for any payload (spacecraft) project. Central to the program is fracture control analysis, which includes the concepts of fail-safe and safe-life, defined as follows:

- a. **Fail-safe:** Ensures that a structural element, because of structural redundancy, will not cause collapse of the remaining structure or have any detrimental effects on mission performance.
- b. **Safe-life:** Ensures that the largest flaw that could remain undetected after non-destructive examination would not grow to failure during the mission.

Functional Tests: The operation of a unit in accordance with a defined operational procedure to determine whether performance is within the specified requirements.

Hardware: As used in this document, there are two major categories of hardware as follows:

- a. **Prototype Hardware:** Hardware of a new design; it is subject to a design qualification test program; it is not intended for flight.
- b. **Flight Hardware:** Hardware to be used operationally in space. It includes the following subsets:
 - (1) **Protoflight Hardware:** Flight hardware of a new design; it is subject to a qualification test program that combines elements of prototype and flight acceptance validation; that is, the application of design qualification test levels and duration of flight acceptance tests.
 - (2) **Follow-On Hardware:** Flight hardware built in accordance with a design that has been qualified either as prototype or as protoflight hardware; follow-on hardware is subject to a flight acceptance test program.

- (3) **Spare Hardware:** Hardware the design of which has been proven in a design qualification test program; it is subject to a flight acceptance test program and is used to replace flight hardware that is no longer acceptable for flight.
- (4) **Re-flight Hardware:** Flight hardware that has been used operationally in space and is to be reused in the same way; the validation program to which it is subject depends on its past performance, current status, and the upcoming mission.

Inspection: The process of measuring, examining, gauging, or otherwise comparing an article or service with specified requirements.

Instrument: See Level of Assembly.

Level of Assembly: The environmental test requirements of GEVS generally start at the component or unit-level assembly and continue hardware/software build through the system level (referred to in GEVS as the payload or spacecraft level). The assurance program includes the part level. Validation testing may also include testing at the assembly and subassembly levels of assembly; for test record keeping these levels are combined into a “subassembly” level. The validation program continues through launch, and on-orbit performance. The following levels of assembly are used for describing test and analysis configurations:

- a. **Part:** A hardware element that is not normally subject to further subdivision or disassembly without destruction of design use. Examples include resistor, integrated circuit, relay, connector, bolt, and gaskets.
- b. **Subassembly:** A subdivision of an assembly. Examples are wire harness and loaded printed circuit boards.
- c. **Assembly:** A functional subdivision of a component consisting of parts or subassemblies that perform functions necessary for the operation of the component as a whole. Examples are a power amplifier and gyroscope.
- d. **Component or unit:** A functional subdivision of a subsystem and generally a self-contained combination of items performing a function necessary for the subsystem’s operation. Examples are electronic box, transmitter, gyro package, actuator, motor, battery. For the purposes of this document, “component” and “unit” are used interchangeably.
- e. **Section:** A structurally integrated set of components and integrating hardware that form a subdivision of a subsystem, module, etc. A section forms a testable level of assembly, such as components/units mounted into a structural mounting tray or panel-like assembly, or components that are stacked.
- f. **Subsystem:** A functional subdivision of a payload consisting of two or more components. Examples are structural, attitude control, electrical power, and communication subsystems. Also included as subsystems of the payload are the science instruments or experiments.
- g. **Instrument:** A spacecraft subsystem consisting of sensors and associated hardware for making measurements or observations in space. For the purposes of this document, an instrument is considered a subsystem (of the spacecraft).
- h. **Module:** A major subdivision of the payload that is viewed as a physical and functional entity for the purposes of analysis, manufacturing, testing, and record keeping. Examples include spacecraft bus, science payload, and upper stage vehicle.
- i. **Payload:** An integrated assemblage of modules, subsystems, etc., designed to perform a specified mission in space. For the purposes of this document, “payload” and “spacecraft” are used interchangeably. Other terms used to designate this level of assembly are Laboratory, Observatory, and satellite.
- j. **Spacecraft:** See Payload. Other terms used to designate this level of assembly are Laboratory, Observatory, and satellite.

Limit Level: The maximum expected flight.

Limited Life Items: Spaceflight hardware (1) that has an expected failure-free life that is less than the projected mission life, when considering cumulative ground operation, storage and on-orbit operation, (2) limited shelf life material used to fabricate flight hardware.

Margin: The amount by which hardware capability exceeds mission requirements

Module: See Level of Assembly.

Monitor: To keep track of the progress of a performance assurance activity; the monitor need not be present at the scene during the entire course of the activity, but he will review resulting data or other associated documentation (see Witness).

Nonconformance: A condition of any hardware, software, material, or service in which one or more characteristics do not conform to requirements. As applied in quality assurance, nonconformances fall into two categories—discrepancies and failures. A discrepancy is a departure from specification that is detected during inspection or process control testing, etc., while the hardware or software is not functioning or operating. A failure is a departure from specification that is discovered in the functioning or operation of the hardware or software.

Offgassing: The emanation of volatile matter of any kind from materials into a manned pressurized volume.

Outgassing: The emanation of volatile materials under vacuum conditions resulting in a mass loss and/or material condensation on nearby surfaces.

Part: See Level of Assembly.

Payload: See Level of Assembly.

Performance Validation: Determination by test, analysis, or a combination of the two that the payload element can operate as intended in a particular mission; this includes being satisfied that the design of the payload or element has been qualified and that the particular item has been accepted as true to the design and ready for flight operations.

Protoflight Testing : See Hardware.

Prototype Testing: See Hardware.

Qualification: See Design Qualification Tests.

Redundancy (of design): The use of more than one independent means of accomplishing a given function.

Repair: A corrective maintenance action performed as a result of a failure so as to restore an item to op within specified limits.

Rework: Return for completion of operations (complete to drawing). The article is to be reprocessed to conform to the original specifications or drawings.

Section: See Level of Assembly.

Similarity, Validation by: A procedure of comparing an item to a similar one that has been verified. Configuration, test data, application and environment should be evaluated. It should be determined that design-differences are insignificant, environmental stress will not be greater in the new application, and that manufacturer and manufacturing methods are the same.

Single Point Failure: A single element of hardware the failure of which would result in loss of mission objectives, hardware, or crew, as defined for the specific application or project for which a single point failure analysis is performed.

Spacecraft: See Level of Assembly.

Subassembly: See Level of Assembly.

Subsystem: See Level of Assembly.

Temperature Cycle: A transition from some initial temperature condition to temperature stabilization at one extreme and then to temperature stabilization at the opposite extreme and returning to the initial temperature condition.

Temperature Stabilization: The condition that exists when the rate of change of temperatures has decreased to the point where the test item may be expected to remain within the specified test tolerance for the necessary duration or where further change is considered acceptable.

Thermal Balance Test: A test conducted to verify the adequacy of the thermal model, the adequacy of the thermal design, and the capability of the thermal control system to maintain thermal conditions within established mission limits.

Thermal-Vacuum Test: A test conducted to demonstrate the capability of the test item to operate satisfactorily in vacuum at temperatures based on those expected for the mission. The test, including the gradient shifts induced by cycling between temperature extremes, can also uncover latent defects in design, parts, and workmanship.

Torque Margin: Torque margin is equal to the torque ratio minus one.

Torque Ratio: Torque ratio is a measure of the degree to which the torque available to accomplish a mechanical function exceeds the torque required.

Total Mass Loss (TML): Total mass of material outgassed from a specimen that is maintained at a specified constant temperature and operating pressure for a specified time.

Unit: See Level of Assembly.

Validation: See Performance Validation.

Vibroacoustics: An environment induced by high-intensity acoustic noise associated with various segments of the flight profile; it manifests itself throughout the payload in the form of directly transmitted acoustic excitation and as structure-borne random vibration.

Workmanship Tests: Tests performed during the environmental validation program to verify adequate workmanship in the construction of a test item. It is often necessary to impose stresses beyond those predicted for the mission in order to uncover defects. Thus random vibration tests are conducted specifically to detect bad solder joints, loose or missing fasteners, improperly mounted parts, etc. Cycling between temperature extremes during thermal-vacuum testing and the presence of electromagnetic interference during EMC testing can also reveal the lack of proper construction and adequate workmanship.

Witness: A personal, on-the-scene observation of a performance assurance activity with the purpose of verifying compliance with project requirements (see Monitor).